



# The floodplain woods of Tuscany: towards a phytosociological synthesis

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## Abstract

The recent Landscape Plan of Tuscany Region pays particular attention towards the floodplain woods, for their conservation concern, landscape, and historical importance. The floodplain forest vegetation is defined as the natural and semi-natural wood vegetation located close to the rivers and submerged only during exceptional flooding. We gathered 180 both published and unpublished relevés coming from Tuscany and carried out in floodplain woods, where *Alnus glutinosa*, *Fraxinus angustifolia* subsp. *oxycarpa*, *Quercus robur*, *Ulmus minor*, *Carpinus betulus*, *Populus nigra*, *P. alba* and *Salix alba* were dominant, alone or in consociation with each other. On this dataset we performed a multivariate analysis, and the resulting groups were characterized by several points of view: floristic, ecological, chorological, by mean of diagnostic species, with the use of EIV. Moreover, their distribution in Tuscany was better defined. According to our results, six associations were found to be present in Tuscany. Thereby, one new association and three new subassociations were proposed. The syntaxonomic arrangement above the association level was discussed, with particular attention to the Italian *Fraxinus angustifolia* subsp. *oxycarpa*-rich communities. Finally, a comparison with the Annex I habitat types (sensu Directive 92/43/EEC) was carried out.

## Keywords

*Alnetea glutinosae*, *Alno glutinosae-Populetea nigrae*, chorology, EIV, interdune woods, NMDS, *Quercetalia pubescens*, syntaxonomy, swampy forests

## Introduction

Floodplain forests are considered one of the most widespread forest communities in Europe (Schnitler et al. 2007) and represent an important biodiversity hotspot (Ward et al. 1999; Geilen et al. 2004). Unfortunately, they are severely endangered ecosystems, threatened by land-use changes. In fact, the shrinking of alluvial forests throughout Europe began in remote times and then strongly intensified in the last two centuries, due to agriculture and urbanization; this phenomenon strongly af-

fected most areas of the floodplains, leading to the process of "insularization" and fragmentation of the remaining forests. Finally, the growing number of invasive alien species such as *Robinia pseudoacacia* L., *Ailanthus altissima* (L.) Swingle, *Acer negundo* L. and *Amorpha fruticosa* L. represents an additional risk today (Schnitler et al. 2007; Lazzaro et al. 2020; Viciani et al. 2020).

For these reasons, the recent landscape plan of the Tuscany Administrative Region identifies the conservation and management of "alluvial soils", as one of the main concerns for conservation (Marson 2016), in order

to respect the Code of Cultural Heritage and Landscape, which was approved as a regional law in the 2015 by the Tuscany Regional Council within the new Landscape Plan. The plan integrates the three main components of the landscape: aesthetic-perceptive (aesthetic values), ecological (environmental values of the landscape) and structural features (relationships between cultural and natural aspects structured over time).

According to many authors (e.g. Ellenberg 1988; Bernetti 2005; Douda et al. 2016), alluvial forests include the vegetation established at a specific distance from the rivers and submerged only during exceptional floods. The soil of such forests is generally deep, with the water level frequently reaching roots of plants. The vegetation that occurs in these ecological conditions can be defined as azonal (Géhu 2006), as it is linked to particular geomorphological and edaphic conditions present in many climatic types, rather than only in a specific climate (Bernetti 2005; Blasi 2010). Alluvial forests are widespread across the continent, covering large areas in central and northern Europe, while representing only relic communities in southern Europe and the Mediterranean. They are dominated by deciduous broadleaves: the black alder (*Alnus glutinosa* (L.) Gartner) in the marshy areas and the English oak (*Quercus robur* L.) in the typical alluvial plains; in our region we also found the elm (*Ulmus minor* Mill.) and southern ash (*Fraxinus angustifolia* Vahl subsp. *oxycarpa* (Willd.) Franco & Rocha Afonso). In suburban areas, where the influence of river dynamics is severely limited (e.g. dead meanders), poplar coenoses (*Populus nigra* L., *P. alba* L. and *P. canescens* (Aiton) Sm.), with elm, and relict stands of white willow (*Salix alba* L.) can be found. According to Biondi and Blasi (2015), Douda et al. (2016) and also recent Italian works (e.g. Spampinato et al. 2019), the European alluvial plain forests can be attributed to two classes: *Alnetea glutinosae* Br.-Bl. and Tx. ex Westhoff et al., 1946, for the swampy woods, and *Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantó ex Rivas-Martínez, Báscones, TE Díaz, Fernández-González et Loidi, 2001, for the periodically flooded riparian forests. On the contrary, Mucina et al. (2016) do not consider as an appropriate solution the use of the class *Salici purpureae-Populetea nigrae* and prefer to attribute part of the alluvial forests to *Alno glutinosae-Populetea albae* P. Fukarek et Fabijanić, 1968, because the concept of *Salici purpureae-Populetea nigrae* (as presented in the original diagnosis) also includes the *Salicetalia purpureae* order, that is the type of the *Salicetea purpureae*, i.e. a shrubby riparian class. We prefer to use *Alno glutinosae-Populetea albae*, in accordance with some recent Italian literature (e.g. Poldini et al., 2020), in order to include only riparian forest vegetation.

The syntaxonomic scheme below the class rank, especially at alliance level, is very intricate and a plethora of classification schemes have been proposed, often based on very few and local surveys.

With this study, we aim to contribute to the phytosociological knowledge of the alluvial forests of Tuscany,

including the true swampy forests dominated by *Alnus glutinosa* and/or *Fraxinus angustifolia* subsp. *oxycarpa*, the suburban forests with *Populus* sp. pl., *Salix alba* and/or *Ulmus minor*, the hygrophilous and meso-hygrophilous woods with *Quercus robur* and the meso-hygrophilous forests dominated by *Carpinus betulus*.

## Matherials and Methods

In order to define and identify in the field floodplain woods, we carried out several literature and field investigations which also led to the publication of an updated map for Tuscany (Gennai et al. 2020). The dataset was extracted from published and unpublished relevés stored in the database of the Laboratory of Phytogeography (Dept. of Biology, University of Florence). We firstly selected the relevés in which the tree species *Alnus glutinosa*, *Fraxinus angustifolia* subsp. *oxycarpa*, *Quercus robur*, *Ulmus minor*, *Populus alba*, *P. nigra*, *P. canescens*, *Salix alba* and *Carpinus betulus*, alone or in association with each other, determined at least the 75% of the canopy cover. In Appendix I we provided references of literature used for the selected relevés. In Appendix II we reported the correspondence between numbers of relevés in original reference and numbers attributed in our tables. We excluded the strictly linear riparian formations. To the obtained data-set, 25 unpublished relevés, surveyed following the classical approach of the Zürich-Montpellier school and further updates (Braun-Blanquet 1964; Dengler et al. 2005, 2008; Biondi 2011), were added. These relevés were carried out in sites at a maximum altitude of 200 m a.s.l. and with maximum inclination of 2°, where the larger parts of the Tuscan floodplain woods are distributed (see Gennai et al. 2020). The final data-set comprised 180 relevés with a total of 425 species. We considered as sporadic the species occurring in less than four relevés and with cover-abundance values  $\leq 1$ ; such species were excluded from the numerical analyses, reducing the total number of species to 152. The Braun-Blanquet cover-abundance scale was transformed according to the ordinal scale proposed by Van der Maarel (1979) and Noest et al. (1989):  $r = 1$ ,  $+ = 2$ ,  $1 = 3$ ,  $2 = 5$ ,  $3 = 7$ ,  $4 = 8$ ,  $5 = 9$ .

The matrix was numerically classified by mean of Cluster Analysis using Ward's method and by mean of NMDS analysis with the Bray-Curtis method as similarity measure; the analyses were performed using PAST software (Hammer et al. 2001).

The diagnostic species were statistically defined by the Phi coefficient of association (Chytrý et al. 2002) and its significance was calculated through a Fisher test. We considered a species as diagnostic of each group if  $\phi > 0,20$ , with  $p < 0,01$  (Douda et al. 2016).

A simplified high-level chorotype was attributed to each species, following Pignatti (2005).

The Ellenberg Indicators Values (Ellenberg et al. 1992) were attributed to species according to Pignatti (2005). We considered the following parameters: Light (L), Tem-

perature (T), Continentality (C), Soil Moisture (U), Soil pH (R) and Nutrients (N). For each relevé, the total indicator value was calculated using the weighted averages of the presence/absence data of the species recorded in the relevé (except for sporadic species). To investigate possible different EIV characters of relevés and groups, the EIV vectors were passively projected onto NMDS ordination.

For the analysis of syntaxonomic data we referred to local and international literature separately cited in each paragraph. In particular, for the woods dominated by *Fraxinus angustifolia* subsp. *oxycarpa* we referred to the recent work by Poldini and Sburlino (2018), and we compared their outcomes with our results, through a NMDS analysis and a synoptic table.

The syntaxonomic scheme at higher ranks follows Biondi et al. (2014a, 2014b, 2015) and Biondi and Blasi (2015), with the exception of *Salici purpureae-Populetea nigrae* class, that was replaced by *Alno glutinosae-Populetea albae* in order to include only forest communities (Mucina et al. 2016; Poldini et al. 2020).

Vascular plant species names follow the Portal to the Flora of Italy (2020) and Pignatti (2017–2019).

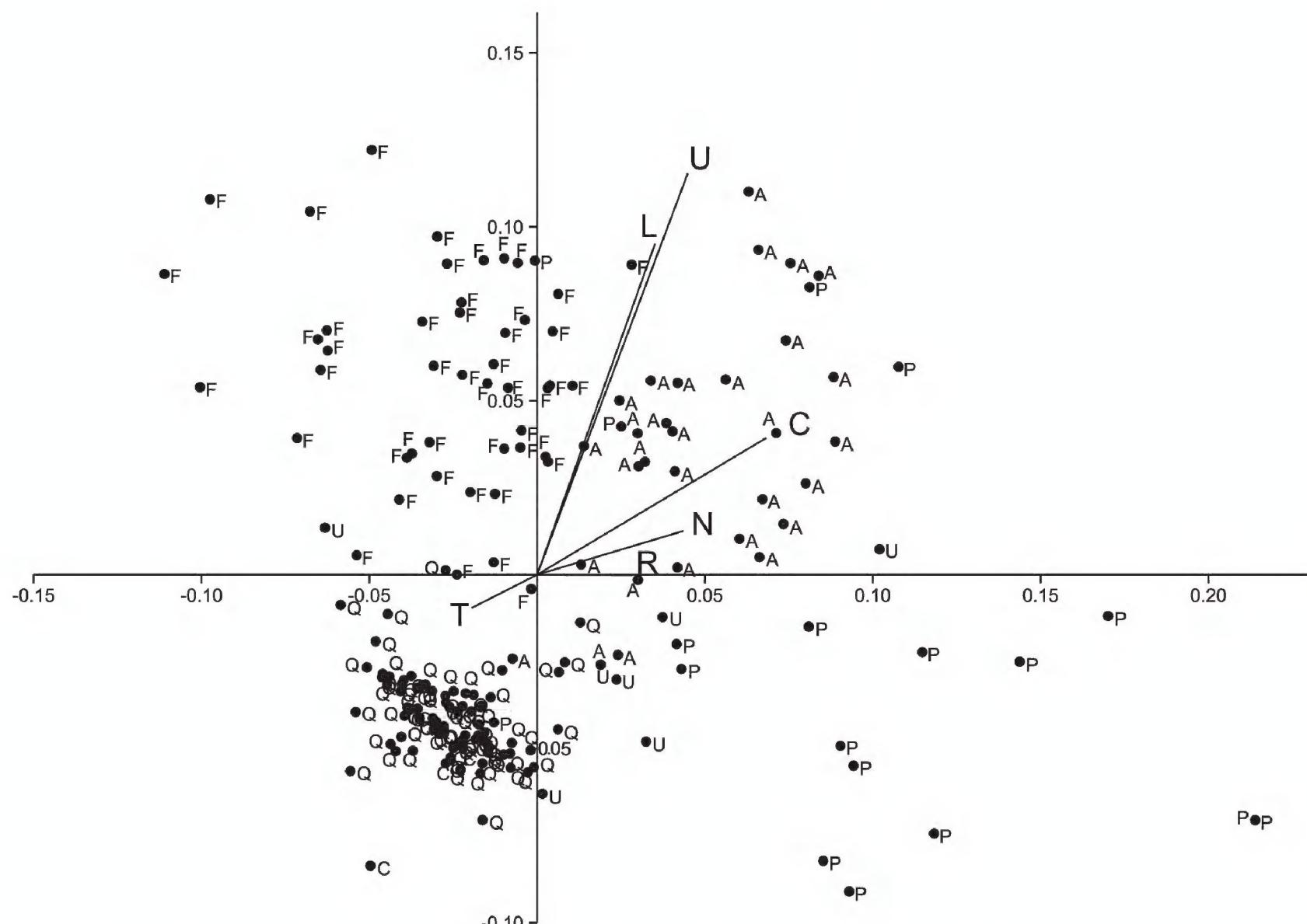
In the descriptions of syntaxa, we indicated as diagnostic the characteristic and differential species reported by the original authors and the species highlighted by the phi analysis. In proper terms, the species indicated by the

original authors as characteristics must be mainly considered as differentials (Géhu 2006).

In the syntaxonomic tables, we also indicated the diagnostic species as reported by the original authors of the syntaxa at the association level, and the phi values of the species (when  $\phi > 20$ ) resulting from the Phi analysis. The attribution of species to *Alnetea*, *Phragmito-Magnocaricetea* and *Alno-Populeta* follows Poldini and Sburlino (2018) and Poldini et al. (2020).

## Results and Discussion

Both the cluster analysis dendrogram (Suppl. material 1: Figure S1) and NMDS results (Fig. 1) confirmed a clear separation between the relevés respectively dominated or co-dominated by *Quercus robur* and *Carpinus betulus* on one side, and *Fraxinus angustifolia* subsp. *oxycarpa*, *Alnus glutinosa*, *Ulmus minor* and *Populus* spp./*Salix alba* on the other side. The Cluster Analysis dendrogram (Suppl. material 1: Figure S1) shows that the first separation divides the mesohygrophyllous woods dominated by *Quercus robur* from the other ones. As regards the NMDS ordination, the swampy forests with *Alnus glutinosa* (A) can be found in the first quadrant, while the linear woods of the interdune wet areas (locally named “lame”) with *Fraxinus*



**Figure 1.** NMDS ordination scatterplot of the relevés of the floodplain woods of Tuscany. A = *Alnus glutinosa* comm.; F = *Fraxinus angustifolia* subsp. *oxycarpa* comm.; P = *Populus* sp./*Salix alba* comm.; U = *Ulmus minor* comm.; C = *Carpinus betulus* comm.; Q = *Quercus robur* comm. The vectors resulting from EIV analysis are superimposed (L: Light, T: Temperature, C: Continentality, U: Soil Moisture, R: Soil pH, N: Nutrients).

*angustifolia* subsp. *oxyacarpa* (F) are placed in the second quadrant. The mesohygrophilous forests with *Quercus robur* (Q) and those dominated by *Carpinus betulus* (C) are in the third quadrant, while the thickets with *Ulmus minor* (U) and the woods with poplars and/or white willow (P) can be mainly found in the fourth quadrant.

The resulting EIV vectors projected onto NMDS ordination (Fig. 1) show that the woods dominated by *Fraxinus angustifolia* subsp. *oxyacarpa* and *Alnus glutinosa* are positively influenced by soil moisture (U), light (L), continentality (C), and negatively influenced (but to a little extent), by temperature (T), while the woods dominated by *Quercus robur* and *Carpinus betulus* show an opposite trend. Nutrients (N) and soil pH (R) seem to affect the ordination to a lesser extent.

Statistical and floristic analyses allowed to recognize six different groups, interpreted as different vegetation types and analyzed through Phi analysis. Diagnostic species of these six groups, together with their frequencies, were reported in Table 1. Diagnostic species were indicated in light grey (phi > 20) and dark grey shading (phi > 30).

The results of the chorological analysis of the vegetation types are reported in Fig. 2.

The distribution in Tuscany of the six types of floodplain forests is shown in Fig. 3.

According to the results of our analysis and on the basis of the literature taken into account, we propose the following syntaxonomic scheme. In general terms, we confirmed the associations already reported for Tuscany, with the exception of some minor syntaxonomic formal changes, and the increase in the diagnostic species due to the increase in the number of relevés considered.

**HYDROCOTYLO VULGARIS-ALNETUM GLUTINOSAE** Gellini, Pedrotti et Venanzoni, 1986. *Holotypus*: Table 1, rel. 26 in Gellini et al. 1986 (corresponding to rel. n. 13 in Table 2 this paper) – Interdune swampy woods dominated by *Alnus glutinosa* (Table 2)

**Diagnostic species:** *Alnus glutinosa*, *Hydrocotyle vulgaris*, *Periploca graeca*, *Thelypteris palustris*, *Lycopus europaeus*, *Solanum dulcamara*, *Equisetum arvense*, *Carex remota*.

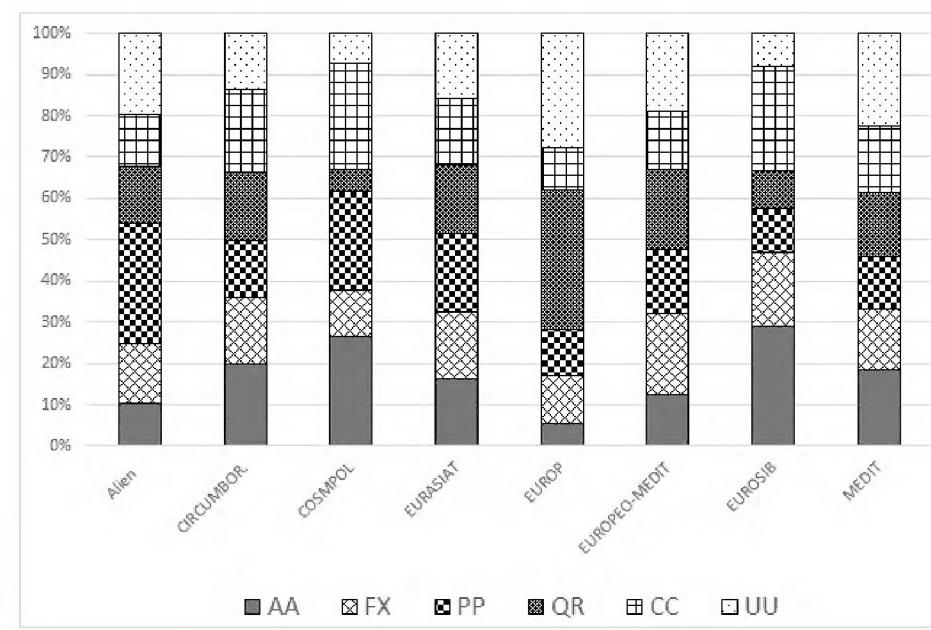
**Dominant trees:** *Alnus glutinosa*, *Fraxinus angustifolia* subsp. *oxyacarpa*

**Ecology and Chorology:** *Alnus glutinosa* tolerates the submersion better than the other tree species considered (Mondino and Bernetti 1998) and it is present only in freshwater. It forms a hygrophilous vegetation type, characterized from a chorological viewpoint by a low percentage of Mediterranean and European-Mediterranean chorotypes and a high presence of species with broad distribution (Cosmopolitan-Circumboreal and Eurosiberian chorotypes, see Fig. 2). According to the EIV analysis (Fig. 1) these woods are located in the first quadrant, positively correlated with L (Light), U (Soil Moisture, C (Continentality), and N (Nutrients), while they are negatively correlated with T (Temperature).

**Distribution in Tuscany** (Fig. 3): These woods were

found in the north-western Tuscany, especially in the plains of Serchio and Arno rivers: Selva di San Rossore (Gellini et al. 1986), Macchia lucchese (Arrigoni 1990), Cerbaie (Arrigoni 1997), Tenuta di San Rossore (Tomei et al. 2004), Tenuta di Migliarino (Sani et al. 2011), Lago di Massaciuccoli (Lastrucci et al. 2017; Viciani et al. 2017), Lago di Porta (Lastrucci et al. 2016).

**Syntaxonomy:** the communities dominated by *Alnus glutinosa* can be referred to the association described by Gellini et al. (1986) for the Selva di San Rossore (PI), and



**Figure 2.** Chorological spectra of the vegetation types. A = *Hydrocotylo-Alnetum glutinosae*; F = *Limnirido-Fraxinetum oxyacarpace*; P = *Dioscoreo-Populetum nigrae*; U = *Periploco-Ulmetum minoris*; C = *Asparago-Carpinetum betuli*; Q = *Fraxino-Quercetum roboris*.



**Figure 3.** Distribution map of the floodplain woods of Tuscany studied. *Hydrocotylo-Alnetum glutinosae* (square); *Limnirido-Fraxinetum oxyacarpace* (black circle); *Dioscoreo-Populetum nigrae* (white circle); *Periploco-Ulmetum minoris* (diamond); *Asparago-Carpinetum betuli* (asterisk); *Fraxino-Quercetum roboris* (triangle).

**Table 1.** Results of Phi analysis. Synoptic table showing the fidelity coefficient of species for each community type. Vegetation types (A: *Alnus glutinosa* comm.; F: *Fraxinus angustifolia* subsp. *oxycarpa* comm.; Q: *Quercus robur* comm.; C: *Carpinus betulus* comm.; U: *Ulmus minor* comm.; P: *Populus* spp. and *Salix alba* comm.).

Vegetation types	A	F	Q	C	U	P
<i>Alnus glutinosa</i> (L.) Gaertn.	47.1	14.7	.	.	.	.
<i>Lycopus europaeus</i> L.	38.8	.	.	.	.	.
<i>Solanum dulcamara</i> L.	38.7	.	.	.	.	.
<i>Equisetum arvense</i> L.	36.8	.	.	.	.	.
<i>Thelypteris palustris</i> Schott	35.7	.	.	.	.	.
<i>Hydrocotyle vulgaris</i> L.	35.6	.	.	.	.	.
<i>Carex remota</i> L.	33.5	.	.	.	.	.
<i>Angelica sylvestris</i> L. subsp. <i>sylvestris</i>	29.5	.	.	.	.	.
<i>Urtica dioica</i> L. subsp. <i>dioica</i>	28.2	.	.	.	.	.
<i>Sambucus nigra</i> L.	27.2	.	.	.	.	.
<i>Carex pendula</i> Huds.	26.1	.	.	.	.	.
<i>Mentha aquatica</i> L. subsp. <i>aquatica</i>	24.4	27.7	.	.	.	.
<i>Potentilla reptans</i> L.	22.9	.	.	.	.	.
<i>Fraxinus angustifolia</i> Vahl subsp. <i>oxycarpa</i> (Willd.) Franco & Rocha Afonso	.	54.5	.	.	.	.
<i>Carex elata</i> All. subsp. <i>elata</i>	.	46.3	.	.	.	.
<i>Limniris pseudacorus</i> (L.) Fuss	.	43.1	.	.	.	.
<i>Ficus carica</i> L.	.	31.7	.	.	.	.
<i>Galium palustre</i> L. s.l.	.	30.7	.	.	.	.
<i>Samolus valerandi</i> L.	.	28	.	.	.	.
<i>Lysimachia nummularia</i> L.	.	28	.	.	.	.
<i>Carex riparia</i> Curtis	.	27.9	.	.	.	.
<i>Juncus acutus</i> L. subsp. <i>acutus</i>	.	24.1	.	.	.	.
<i>Leucojum aestivum</i> L. subsp. <i>aestivum</i>	.	24.1	.	.	.	.
<i>Periploca graeca</i> L.	.	24	.	.	.	.
<i>Agrostis stolonifera</i> L.	.	23.4	.	.	.	.
<i>Juncus articulatus</i> L. subsp. <i>articulatus</i>	.	22.3	.	.	.	.
<i>Juncus inflexus</i> L. subsp. <i>inflexus</i>	.	18.8	.	.	.	.
<i>Carex otrubae</i> Podp.	.	14.4	.	.	.	.
<i>Quercus robur</i> L. subsp. <i>robur</i>	.	.	54.9	.	.	.
<i>Cornus mas</i> L.	.	.	42.9	.	.	.
<i>Lonicera caprifolium</i> L.	.	.	40.4	.	.	.
<i>Acer campestre</i> L.	.	.	40.3	.	.	.
<i>Luzula forsteri</i> (Sm.) DC.	.	.	39.2	.	.	.
<i>Ajuga reptans</i> L.	.	.	36.1	.	.	.
<i>Ligustrum vulgare</i> L.	.	.	36.1	.	.	.
<i>Chamaeiris foetidissima</i> (L.) Medik.	.	.	35	.	.	.
<i>Quercus ilex</i> L. subsp. <i>ilex</i>	.	.	31.4	.	.	.
<i>Crataegus monogyna</i> Jacq.	.	.	29.6	.	.	.
<i>Moehringia trinervia</i> (L.) Clairv.	.	.	29.4	.	.	.
<i>Carex sylvatica</i> Huds.	.	.	29.3	.	.	.
<i>Ruscus aculeatus</i> L.	.	.	28.6	.	.	.
<i>Cardamine pratensis</i> L.	.	.	28.4	.	.	.
<i>Arctium lappa</i> L.	.	.	28.1	.	.	.
<i>Cyclamen repandum</i> Sm. subsp. <i>repandum</i>	.	.	28.1	.	.	.
<i>Geum urbanum</i> L.	.	.	27.5	.	.	.
<i>Fraxinus ornus</i> L. subsp. <i>ornus</i>	.	.	27	.	.	.
<i>Hedera helix</i> L. subsp. <i>helix</i>	.	.	26.8	.	.	.
<i>Viola reichenbachiana</i> Jord. ex Boreau	.	.	24.8	.	.	.
<i>Myosotis sylvatica</i> Hoffm. subsp. <i>sylvatica</i>	.	.	24.5	.	.	.
<i>Holcus lanatus</i> L. subsp. <i>lanatus</i>	.	.	23.9	.	.	.
<i>Veronica montana</i> L.	.	.	23.6	.	.	.
<i>Brachypodium sylvaticum</i> (Huds.) P.Beauv. subsp. <i>sylvaticum</i>	.	.	22.4	.	.	.
<i>Ulmus minor</i> Mill. subsp. <i>minor</i>	.	.	20.9	.	.	.
<i>Clematis vitalba</i> L.	.	.	19.9	.	.	.
<i>Quercus cerris</i> L.	.	.	19.7	.	.	.
<i>Stellaria media</i> (L.) Vill. subsp. <i>media</i>	.	.	19.4	.	.	.
<i>Laurus nobilis</i> L.	.	.	16.4	.	.	.
<i>Euonymus europaeus</i> L.	.	.	16	.	.	.
<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>aquilinum</i>	.	.	14.2	.	.	.
<i>Robinia pseudoacacia</i> L.	.	.	7.2	.	.	.
<i>Ilex aquifolium</i> L.	.	.	99.2	.	.	.
<i>Polygonatum multiflorum</i> (L.) All.	.	.	99.2	.	.	.

**Table 1.** Continuation.

Vegetation types	A	F	Q	C	U	P
<i>Anemonoides nemorosa</i> (L.) Holub	.	.	.	97	.	.
<i>Corylus avellana</i> L.	.	.	.	94	.	.
<i>Lonicera etrusca</i> Santi	.	.	.	92.2	.	.
<i>Malus sylvestris</i> (L.) Mill.	.	.	.	91.7	.	.
<i>Carpinus betulus</i> L.	.	.	4.9	87	.	.
<i>Asparagus tenuifolius</i> Lam.	.	.	.	78.1	.	.
<i>Festuca heterophylla</i> Lam.	.	.	.	77.1	.	.
<i>Mespileus germanica</i> L.	.	.	.	76.2	.	.
<i>Rubus hirtus</i> Waldst. & Kit. group	.	.	.	75.3	.	.
<i>Sorbus torminalis</i> (L.) Crantz	.	.	.	75.2	.	.
<i>Crataegus laevigata</i> (Poir.) DC.	.	.	.	73.5	.	.
<i>Dioscorea communis</i> (L.) Caddick & Wilkin	.	.	.	61.9	.	.
<i>Rhamnus alaternus</i> L. subsp. <i>alaternus</i>	.	.	.		82.2	.
<i>Smilax aspera</i> L.	.	.	.		69.5	.
<i>Rubia peregrina</i> L.	.	.	.		68	.
<i>Rosa sempervirens</i> L.	.	.	.		66.3	.
<i>Phillyrea angustifolia</i> L.	.	.	.		59.2	.
<i>Salix alba</i> L.	.	.	.			58.6
<i>Populus nigra</i> L.	.	.	.			49.3
<i>Rubus caesius</i> L.	.	.	.			44.5
<i>Populus alba</i> L.	.	.	.			44.2
<i>Xanthium italicum</i> Moretti	.	.	.			43.9
<i>Humulus lupulus</i> L.	.	.	.			43
<i>Salix cinerea</i> L.	.	.	.			42.2
<i>Galega officinalis</i> L.	.	.	.			35.8
<i>Pulicaria dysenterica</i> (L.) Bernh.	.	.	.			35.3
<i>Cornus sanguinea</i> L.	.	.	.			26.4
<i>Phragmites australis</i> (Cav.) Trin. ex Steud. subsp. <i>australis</i>	.	.	.			22.7

previously reported by Arrigoni (1998) for Tuscany and Sburlino et al. (2011) for northern and central Italy.

**LIMNIRIDO PSEUDACORI-FRAXINETUM OXYCARPAE ass. nova. Holotypus** relevé 23 in Table 3 this paper – Swampy woods dominated by *Fraxinus angustifolia* subsp. *oxycarpa* (Table 3)

**Diagnostic species:** *Fraxinus angustifolia* subsp. *oxycarpa*, *Carex elata*, *Ficus carica*, *Galium palustre*, *Limniris pseudacorus*, *Samolus valerandi*, *Leucojum aestivum*, *Lysimachia nummularia*, *Carex riparia*, *Periploca graeca*.

**Dominant trees:** *Fraxinus angustifolia* subsp. *oxycarpa*, *Alnus glutinosa*.

**Ecology and Chorology:** *Fraxinus angustifolia* subsp. *oxycarpa* can tolerate short periods of moderate water deficit and low concentrations of salt in soil waters. In general terms, this species is more Mediterranean, relatively more thermophilous than *Alnus glutinosa*. From a chorological viewpoint, these woods are firstly characterized by the European-Mediterranean and Eurasian chorotypes (Fig. 2). According to the EIV analysis (Fig. 1), these woods are positively related to Soil Moisture (U) and Light (L).

**Distribution in Tuscany** (Fig. 3): These woods occupy the interdune areas along the Tyrrhenian coasts, such as San Rossore (Gellini et al. 1986), Bosco dell’Ulivo (Coaro 1987), Castagneto Carducci (Foggi et al. 2000), Macchia Lucchese (Arrigoni 1990), Tenuta del Tombolo di San Rossore (Tomei et al. 2004), Tenuta di Migliarino (Sani

et al. 2011), Tenuta di Coltano (Bertacchi and Lombardi 2016) and Padule di Bolgheri.

**Syntaxonomy:** Gellini et al. (1986) referred this type of woods to the *Carici remotae-Fraxinetum oxycarpae* Pedrotti corr. Pedrotti 1993, a riparian forest association. The woods dominated by *Fraxinus angustifolia* subsp. *oxycarpa* here presented, instead, are clearly characterized by a higher presence of swamp species with respect to riverine *Carici remotae-Fraxinetum oxycarpae* coenoses. For example, species like *Stachys sylvatica*, *Symphytum tuberosum*, *Ranunculus lanuginosus* are not present (Gellini et al. 1986), while several *Carex* species were frequently found.

Gellini et al. (1986) suggested the establishment of a new subassociation, *Carici-Fraxinetum oxycarpae alnetosum glutinosae*, but the name is invalid on the basis of Art. 5 of the ICPN (Theurillat et al. 2021). Furthermore, the two relevés attributed to this subassociation were included in the *Hydrocotylo-Alnetum* table, therefore, we decided to not validate the subassociation. However, it must be noted that the relevés 33–47 of Table 3, where *Alnus glutinosa* has high cover values, show a transition to the swampy woods of *Hydrocotylo-Alnetum*.

*Fraxinus angustifolia* subsp. *oxycarpa*, in Tuscany, has broad ecological needs; according to Mondino and Bennetti (1998) it can be found in swamp areas with *Alnus glutinosa* and *Quercus robur*, riparian habitats with *Ulmus minor* and, finally, in hilly meso-hygrophilous conditions with *Quercus cerris* (Scoppola and Filesi 1995; Foggi et al. 2000; Terzi et al. 2020). Marshy woods are often character-

**Table 2.** *Hydrocotylo vulgaris-Alnetum glutinosae* Pedrotti, Gellini & Venanzoni 1986. Species reported by the original authors as diagnostic are written in italics.

**Table 2.** Continuation.

**Table 3.** *Limnirido pseudacori-Fraxinetum oxycarpe ass. nova*. Rels 1–32: typical aspects; rels 33–47: transition aspects to *Hydrocotoyo-Alnetum*.

**Table 3.** Continuation.

ized by a vegetation mosaic of forest stands with *Juncetalia maritimi*, *Magnocaricion elatae* and *Phragmition*. A similar situation is reported for the Bosco della Mesola site, in North-Eastern Italian Adriatic coast (Piccoli et al. 1983; Piccoli and Gerdol 1984; Gerdol et al. 2018). In a similar landscape context, for the Tuscan north-western Thyrrenian coast, Tomei et al. (2004) proposed the new association *Carici elatae-Fraxinetum oxycarpae*, not validly published according to the Art. 5 of the ICPN (Theurillat et al. 2021). Moreover, it was based on only two relevés that, in our opinion, are not representative of a wood, being the cover value of the tree layer very low. For these reasons, we decided not to validate this name and we here propose to attribute these coenoses to a new association named *Limnirido pseudacori-Fraxinetum oxycarpae*, which is characterized by the presence of a high contingent of *Phragmiti-Magnocariceta* species compared to other similar associations, i.e. *Fraxino-Quercetum roboris* observed for the low interdune swamp areas of Migliarino-San Rossore by Gellini et al. (1986), *Carici remotae-Fraxinetum oxycarpae* reported by Pedrotti (1970, 1993), Gellini et al. (1986), Mondino and Bernetti (1998), Arrigoni (1998), Mercadal and Vilar (2013) and, finally, *Alno-Fraxinetum oxycarpae* (Arrigoni 1998).

The floristic differences between the other associations dominated by *Fraxinus angustifolia* subsp. *oxycarpa* described for Italy (Tables 1 and 2 in Poldini and Sburlino 2018) and the similar coenoses detected in the Tuscan floodplain woods are displayed in a synoptic table (Table 4) and in the dedicated NMDS ordination (Fig. 4). Table 4 shows that columns on the left side (columns 1–12) can be assigned to the swampy alliance *Frangulo alni-Fraxinion*, while those at the right side (columns 13–20) can be attributed to the riparian alliance *Carici remotae-Fraxinion* (Poldini and Sburlino 2018). According to this scheme, we refer the association *Limnirido-Fraxinetum oxycarpae* to the alliance *Frangulo-Fraxinion*. This interpretation was also confirmed by the cluster analysis (Suppl. material 1: Figure S1) through which the riparian woods are clustered together and separated from the swampy woods. Even if these coenoses also host a high rate of *Alno-Populeta* and *Populetalia* species (Table 3), the attribution of this new association to the *Alnetea* and *Alnetalia* is also justified for its ecological position, as it is typically located in the interdune swamps. Also, the *Fraxinus angustifolia* subsp. *oxycarpa* communities recently indicated for Corsica (Gauberville et al. 2018) as *Carici remotae-Fraxinetum* can be probably attributed to *Limnirido-Fraxinetum*, considering their floristic composition and ecology.

In the end, we note that in Tuscany the distinction between the alliances *Alnion glutinosae* and *Frangulo-Fraxinion* is not so clear, as many diagnostic species are in common, and a comprehensive work devoted to clarify this problem is needed.

**FRAZINO OXYCARPAE-QUERCETUM ROBORIS** Gellini, Pedrotti et Venanzoni, 1986. *Holotypus*: Table 3, rel.

14 in Gellini, Pedrotti et Venanzoni, 1986 (corresponding to rel. n. 40 in Suppl. material 2: Table S1) – Mesohygrophilous forests dominated by *Quercus robur* and *Fraxinus angustifolia* subsp. *oxycarpa* (Suppl. material 2: Table S1)

**Diagnostic species:** *Quercus robur*, *Cornu mas*, *Acer campestre*, *Luzula forsteri*, *Moheringia trinervia*, *Chamaeiris foetidissima*, *Lonicera caprifolium*, *Ruscus aculeatus*, *Viola reichembachiana*, *Ajuga reptans*, *Ligustrum vulgare*, *Veronica montana*.

**Dominant trees:** *Quercus robur*, *Fraxinus angustifolia* subsp. *oxycarpa*, *Acer campestre*, *Carpinus betulus*, *Ulmus minor*, *Quercus ilex* (only in the *lauretosum nobilis* subassociation).

**Ecology and Chorology:** Meso-hygrophilous, Mediterranean woods developing on fertile and deep soils. The chorotypes spectrum is very similar to that of the *Fraxinus angustifolia* subsp. *oxycarpa* woods, apart for a slight increase in European species (Figure 2). These communities were found in the more elevated areas of the swamps, in contact with the climatic woods, which act as suppliers of many euryoecious species, tolerating seasonal variations of hygromorphic conditions. According to the EIV analysis (Fig. 1), these woods are positively related to Temperature (T), and negatively to Soil Moisture (U), Continentality (C) and Light (L).

**Distribution in Tuscany (Fig. 3):** These communities were found in San Rossore (Gellini et al. 1986; Tomei et al. 2004), Bosco dell'Ulivo (Coaro 1987), Macchia Lucchese (Arrigoni 1990), Cerbaie (Arrigoni 1997), Bosco dei Renacci (Viciani and Gabellini 2012), Bosco di Chiusi (Tomei and Cenni 1986), Coltano (Bertacchi and Lombardi 2016), and according to Gellini et al. (1986), also in Migliarino and Viareggio.

**Syntaxonomy:** English oak forests in Tuscany were originally described by Gellini et al. (1986) for the Selva di San Rossore and referred to the association *Fraxino oxycarpae-Quercetum roboris* Gellini, Pedrotti, Venanzoni 1986. The presence of the association was then confirmed by Mondino and Bernetti (1998) and Arrigoni (1998) for the same areas. The association can be divided into four subassociations (Suppl. material 2: Table S1):

1. subass. *typicum* Rels 1–45 in Suppl. material 2: Table S1; it represents the typical aspects of the association (*holotypus* – the same of the association – Table 3, rel. 14 in Gellini et al. 1986).
2. *carpinetosum betuli* Gellini, Pedrotti, Venanzoni 1986 ex Gennai et al. subass. *nova hoc loco* (*lectotypus*: rel. 19 Table 3, in Gellini et al. 1986, corresponding to rel. n. 50 in Suppl. material 2: Table S1; *lectotypus hoc loco*) Rels 46–52 in Suppl. material 2: Table S1; it is differentiated by the dominance of *Carpinus betulus* and by the presence of *Pteridium aquilinum*. This subassociation was reported but not validly typified by Gellini et al. (1986) (Art. 5 of the ICPN – Theurillat et al. 2021), so here we validate this name. These communities can be interpreted as a transition to zonal woody vegetation.

**Table 4.** Synoptic table of *Fraxinus angustifolia* subsp. *oxycarpa* communities, including Tuscan relevés and Italian relevés by Poldini and Sburlino (2018). Column legend: 1: Tuscany, Macchia Lucchese (Arrigoni, 1990); 2: Tuscany, Tenuta di San Rossore (Tomei et al., 2004); 3: Tuscany, Selva di San Rossore (Gellini et al., 1986); 4: Tuscany, Tenuta di Migliarino (Sani et al., 2011); 5: Tuscany, Bosco dell'Ulivo (Coaro, 1987); 6: Tuscany, Tenuta del Tombolo di Pisa (AAVV, 2005); 7–20: from tables 1 and 2 by Poldini and Sburlino (2018); 7: Emilia-Romagna; 8: Emilia-Romagna; 9: Latium; 10: Croatia; 11: Croatia; 12: Friuli-Venezia Giulia; 13: Abruzzo; 14: Abruzzo; 15: Apulia; 16: Abruzzo; 17: Friuli-Venezia Giulia and Veneto; 18: Campania; 19: Emilia-Romagna; 20: Marche. Association abbreviation legend: Lim-Fx: *Limnirido pseudacori-Fraxinetum*; Cla-Fx: *Cladio marisci-Fraxinetum*; Leu-Fx: *Leucojo verni-Fraxinetum*; Val-Fx: *Valeriano dioicae-Fraxinetum*; Crem-Fx: *Carici remotae-Fraxinetum*; Lys-Fx: *Lysimachio nummulariae-Fraxinetum*; Rub-Fx: *Rubo caesi-Fraxinetum*; Sal-Fx: *Salici apenninae-Fraxinetum*.

Column n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Association abbreviation	Lim-Fx1	Lim-Fx2	Lim-Fx3	Lim-Fx4	Lim-Fx5	Lim-Fx6	Cla-Fx1	Cla-Fx2	Cla-Fx3	Leu-Fx1	Leu-Fx2	Val-Fx	Crem-Fx1	Crem-Fx2	Crem-Fx3	Crem-Fx4	Lys-Fx	Rub-Fx	Rub-Ulm	Sal-Fx	
<b>Frangulo-Fraxinon, Alnetalia, Alnetea, Magnocaricion elatae species n.</b>	14	8	9	10	4	8	16	8	12	19	13	14	0	3	2	1	5	1	2	0	
<b>Carici-Fraxinon, Populetalia, Alno-Populetea species n.</b>	5	6	7	8	6	5	4	2	2	3	4	2	11	18	16	5	14	11	6	7	
<b>Frangulo-Fraxinon, Alnetalia, Alnetea</b>																					
<i>Alnus glutinosa</i> (L.) Gaertn.	100	22	86	82	10	11	22	·	·	17	100	50	·	·	·	·	·	·	·	·	
<i>Dryopteris carthusiana</i> (Vill.) H.P.Fuchs	·	·	·	·	·	·	·	·	·	13	60	·	·	·	·	·	·	·	·	·	
<i>Frangula alnus</i> Mill. subsp. <i>alnus</i>	90	·	·	·	10	22	100	100	100	17	80	100	·	·	·	·	·	40	·	·	
<i>Galium palustre</i> L. s.l.	30	56	100	53	30	33	11	86	83	100	100	83	·	·	·	56	17	·	·	·	
<i>Hydrocotyle vulgaris</i> L.	·	11	14	12	·	·	·	29	·	·	·	·	·	·	·	·	·	·	·	·	
<i>Lycopus europaeus</i> L.	50	·	·	·	·	·	67	14	33	96	80	67	·	47	50	·	·	29	10	·	
<i>Cladium mariscus</i> (L.) Pohl	·	·	·	·	·	·	56	100	50	·	·	33	·	·	·	·	·	·	·	·	
<i>Salix cinerea</i> L.	10	·	·	·	·	·	44	·	50	·	·	17	·	·	·	·	·	·	·	·	
<i>Thelypteris palustris</i> Schott	50	·	·	·	·	11	22	71	·	·	·	50	·	·	·	·	·	·	·	·	
<b>Magnocaricion elatae</b>																					
<i>Mentha aquatica</i> L. subsp. <i>aquatica</i>	30	11	43	82	·	11	89	57	83	91	40	33	·	·	·	·	·	·	·	·	
<i>Limniris pseudacorus</i> (L.) Fuss	60	11	43	71	·	22	89	·	50	100	100	67	·	29	17	·	67	·	·	·	
<i>Carex elata</i> All. subsp. <i>elata</i>	60	11	43	41	·	11	78	·	17	26	·	100	·	·	·	·	·	·	·	·	
<i>Lythrum salicaria</i> L.	20	17	57	18	·	56	56	·	100	100	·	67	·	·	·	·	·	·	·	·	
<i>Lysimachia vulgaris</i> L.	70	·	29	12	·	·	89	·	67	78	100	50	·	·	·	·	·	·	·	·	
<i>Carex riparia</i> Curtis	10	·	43	35	·	·	56	·	·	43	·	·	·	·	·	·	·	·	·	·	
<i>Alisma plantago-aquatica</i> L.	20	·	·	·	·	22	·	·	30	40	·	·	·	·	·	·	·	·	·	·	
<i>Rumex triangulivalvis</i> (Danser) Rech.f.	·	·	·	20	·	11	·	·	4	·	·	·	·	·	·	·	·	·	·	·	
<i>Stachys palustris</i> L.	·	·	·	·	·	78	·	·	91	100	·	·	·	·	·	·	·	·	·	·	
<i>Alisma lanceolatum</i> With.	10	·	·	·	·	·	·	·	100	·	·	·	·	·	·	·	·	·	·	·	
<i>Glyceria fluitans</i> (L.) R.Br.	·	·	·	·	·	·	·	·	39	20	·	·	·	·	·	·	·	·	·	·	
<i>Poa palustris</i> L. subsp. <i>palustris</i>	·	11	·	·	·	·	·	·	·	20	·	·	·	·	·	·	·	·	·	·	
<i>Carex acutiformis</i> Ehrh.	·	·	·	·	·	·	86	·	4	·	·	·	·	·	·	67	·	·	·	·	
<i>Eupatorium cannabinum</i> L. subsp. <i>cannabinum</i>	·	·	6	·	·	·	33	·	40	67	·	6	·	·	17	·	·	·	·	·	
<i>Cyperus longus</i> L.	·	·	·	·	·	·	33	·	·	·	·	·	·	·	·	·	·	·	·	·	
<i>Oenanthe aquatica</i> (L.) Poir.	·	·	·	·	·	·	13	·	·	·	·	·	·	·	·	·	·	·	·	·	
<i>Sparganium erectum</i> L.	·	·	·	·	·	22	·	·	·	·	·	17	·	·	·	·	·	·	·	·	·
<i>Veronica beccabunga</i> L.	·	·	·	·	·	·	·	·	·	·	·	50	·	·	·	·	·	·	·	·	·
<i>Phalaris arundinacea</i> L. subsp. <i>arundinacea</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	50	·	·	·	·	·
<b>Carici-Fraxinon, Populetalia, Alno-Populetea</b>																					
<i>Carex pendula</i> Huds.	20	33	57	12	·	·	·	·	·	·	·	·	80	94	100	86	67	57	100	33	
<i>Brachypodium sylvaticum</i> (Huds.) P.Beauv. subsp. <i>sylvaticum</i>	10	56	43	18	10	44	·	·	·	·	·	·	60	59	100	·	67	86	60	·	
<i>Carex remota</i> L.	20	61	100	35	30	33	·	·	·	43	80	·	100	47	·	·	83	·	·	·	
<i>Vitis vinifera</i> L.	10	·	·	6	10	·	22	29	67	·	·	·	·	29	33	·	14	20	·	·	
<i>Convolvulus sepium</i> L.	·	·	·	12	·	11	44	29	83	·	40	17	·	·	·	·	33	14	·	·	
<i>Populus nigra</i> L.	20	·	14	12	·	33	·	·	·	·	50	·	12	100	·	67	·	·	67	·	
<i>Rumex sanguineus</i> L.	·	22	86	6	·	·	·	·	39	80	·	100	88	100	·	67	·	·	·	·	
<i>Geum urbanum</i> L.	·	·	·	·	22	·	·	·	·	·	60	·	20	18	67	57	·	57	·	·	
<i>Ranunculus lanuginosus</i> L.	·	·	·	30	11	·	·	·	·	·	·	·	100	88	83	86	·	86	·	·	
<i>Dioscorea communis</i> (L.) Caddick & Wilkin	·</																				

**Table 4.** Continuation.

Column n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Association abbreviation	Lim-Fx1	Lim-Fx2	Lim-Fx3	Lim-Fx4	Lim-Fx5	Lim-Fx6	Cla-Fx1	Cla-Fx2	Cla-Fx3	Leu-Fx1	Leu-Fx2	Val-Fx	Crem-Fx1	Crem-Fx2	Crem-Fx3	Crem-Fx4	Lys-Fx	Rub-Fx	Rub-Ulm	Sal-Fx
<i>Frangulo-Fraxinion, Alnetalia, Alnetea, Magnocaricion elatae species n.</i>	14	8	9	10	4	8	16	8	12	19	13	14	0	3	2	1	5	1	2	0
<i>Carici-Fraxinion, Populetalia, Alno-Populetea species n.</i>	5	6	7	8	6	5	4	2	2	3	4	2	11	18	16	5	14	11	6	7
<i>Clematis viticella</i> L.	·	·	·	·	·	·	·	·	·	·	·	·	35	·	·	83	43	90	·	
<i>Sympyton tuberosum</i> L. subsp. <i>angustifolium</i> (A.Kern.) Nyman	·	·	·	·	·	·	·	·	·	·	·	20	18	100	·	·	57	·	·	
<i>Sambucus nigra</i> L.	·	·	14	·	·	·	·	·	·	·	·	·	17	·	83	29	·	·	·	
<i>Malus sylvestris</i> (L.) Mill.	·	·	·	12	40	·	·	·	·	·	·	·	17	·	·	22	·	·	·	
<i>Humulus lupulus</i> L.	·	·	·	·	·	·	·	·	·	·	·	·	12	67	·	17	·	·	·	
<i>Salix purpurea</i> L.	·	·	·	·	·	·	·	·	·	·	·	·	53	·	·	·	·	44	·	
<i>Chacerophyllum temulum</i> L.	·	·	·	·	·	·	·	·	·	·	·	47	·	·	·	·	·	·	·	
<i>Salix triandra</i> L. subsp. <i>triandra</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	11	·	
<b>Other species</b>																				
<i>Fraxinus angustifolia</i> Vahl subsp. <i>oxycarpa</i> (M.Bieb. ex Willd.) Franco & Rocha Afonso	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
<i>Ulmus minor</i> Mill. subsp. <i>minor</i>	40	83	100	47	50	100	44	86	·	22	80	50	100	94	100	86	67	86	100	67
<i>Rubus ulmifolius</i> Schott	70	89	100	41	70	89	22	71	100	·	·	80	100	83	78	17	43	·	67	·
<i>Quercus robur</i> L. subsp. <i>robur</i>	·	56	57	6	70	56	56	71	67	48	80	·	80	18	·	67	·	100	11	
<i>Populus alba</i> L.	60	34	14	36	30	44	78	100	·	·	·	100	82	·	14	·	14	100	78	
<i>Cornus sanguinea</i> L.	·	43	12	·	56	11	43	·	·	67	60	65	67	89	83	43	80	100	·	
<i>Prunella vulgaris</i> L. subsp. <i>vulgaris</i>	20	17	29	24	·	·	·	·	17	60	17	80	12	83	56	·	14	·	44	
<i>Ligustrum vulgare</i> L.	20	·	·	·	60	56	·	43	·	·	17	·	76	83	22	17	57	50	11	
<i>Ruscus aculeatus</i> L.	20	39	·	·	80	56	·	29	·	·	50	80	53	83	89	·	100	·	11	
<i>Potentilla reptans</i> L.	·	28	71	12	10	22	·	43	33	30	·	20	35	·	·	·	·	·	11	
<i>Ranunculus repens</i> L.	·	11	100	·	20	11	·	·	100	60	67	47	50	·	33	·	·	·	11	
<i>Agrostis stolonifera</i> L.	·	39	86	41	·	44	11	57	50	13	20	·	·	·	·	43	·	·	·	
<i>Hedera helix</i> L. subsp. <i>helix</i>	40	67	57	29	80	67	11	57	67	·	·	50	80	88	50	100	67	100	·	44
<i>Smilax aspera</i> L.	20	·	6	80	22	·	·	50	·	·	40	47	17	22	29	·	·	·	·	
<i>Crataegus monogyna</i> Jacq.	40	56	43	12	70	56	67	71	·	·	100	·	·	100	17	71	·	89	·	
<i>Carex otrubae</i> Podp.	·	17	·	18	30	22	·	·	67	·	·	·	50	11	17	14	·	·	·	
<i>Clematis vitalba</i> L.	10	·	29	·	10	44	·	·	·	·	20	18	50	·	·	30	22	·	·	
<i>Euonymus europaeus</i> L.	·	·	29	6	50	56	·	·	·	·	·	76	83	56	17	71	·	·	·	
<i>Quercus ilex</i> L. subsp. <i>ilex</i>	30	6	·	6	30	44	·	43	33	·	·	6	·	·	14	·	·	·	·	
<i>Acer campestre</i> L.	10	28	29	·	10	11	·	·	17	·	20	17	20	59	33	33	100	14	40	55
<i>Carex flacca</i> Schreb. subsp. <i>flacca</i>	10	6	·	·	·	11	·	43	67	·	·	·	22	29	·	44	·	·	·	
<i>Carex sylvatica</i> Huds.	·	22	71	·	·	22	·	·	·	·	20	18	·	100	17	14	·	·	·	
<i>Leucojum aestivum</i> L. subsp. <i>aestivum</i>	·	·	14	18	·	·	11	·	·	100	60	100	·	24	·	67	·	·	·	
<i>Lysimachia nummularia</i> L.	·	22	43	12	20	·	44	·	·	100	100	·	·	·	·	83	·	·	·	
<i>Poa trivialis</i> L.	·	11	86	·	·	·	·	·	·	83	80	·	100	35	83	·	50	·	·	
<i>Viola reichenbachiana</i> Jord. ex Boreau	·	44	43	·	50	22	·	·	·	·	·	20	12	·	·	17	14	·	·	
<i>Prunus spinosa</i> L. subsp. <i>spinosa</i>	80	6	29	·	70	56	89	86	·	·	·	60	12	83	44	50	57	100	100	
<i>Rhamnus cathartica</i> L.	40	·	14	6	·	11	78	14	·	·	50	·	·	·	·	·	·	·	·	
<i>Asparagus acutifolius</i> L.	·	·	·	·	20	11	·	·	·	·	·	24	17	22	·	86	·	11	·	
<i>Crataegus laevigata</i> (Poir.) DC.	·	·	·	·	·	·	·	·	·	60	80	71	·	67	17	14	30	·	·	
<i>Lonicera caprifolium</i> L.	·	·	·	·	70	67	·	·	·	·	20	59	·	·	17	29	·	33	·	
<i>Rosa sempervirens</i> L.	·	·	·	·	30	22	·	·	·	·	·	59	83	44	·	100	·	22	·	
<i>Rubia peregrina</i> L.	10	·	·	·	70	56	·	·	·	·	·	71	33	11	·	86	·	·	·	
<i>Urtica dioica</i> L. subsp. <i>dioica</i>	·	11	57	·	·	11	·	·	57	60	·	24	·	67	·	·	·	·	·	
<i>Rubus caesius</i> L.	50	·	·	·	·	11	29	·	26	60	3									

**Table 4.** Continuation.

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Column n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Association abbreviation	Lim-Fx1	Lim-Fx2	Lim-Fx3	Lim-Fx4	Lim-Fx5	Lim-Fx6	Cla-Fx1	Cla-Fx2	Cla-Fx3	Leu-Fx1	Leu-Fx2	Val-Fx	Crem-Fx1	Crem-Fx2	Crem-Fx3	Crem-Fx4	Lys-Fx	Rub-Fx	Rub-Ulm	Sal-Fx
<i>Frangulo-Fraxinion, Alnetalia, Alnetea, Magnocaricion elatae species n.</i>	14	8	9	10	4	8	16	8	12	19	13	14	0	3	2	1	5	1	2	0
<i>Carici-Fraxinion, Populetalia, Alno-Populetea species n.</i>	5	6	7	8	6	5	4	2	2	3	4	2	11	18	16	5	14	11	6	7
<i>Quercus pubescens</i> Willd. subsp. <i>pubescens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	55	
<i>Rorippa amphibia</i> (L.) Besser	.	.	.	.	.	22	.	.	87	.	.	.	.	.	.	.	.	.	.	
<i>Rumex conglomeratus</i> Murray	.	6	.	.	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Schoenus nigricans</i> L.	.	11	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Sium latifolium</i> L.	.	.	.	.	.	33	.	83	.	.	.	.	.	.	.	.	.	.	.	
<i>Sympyrum officinale</i> L.	.	.	.	.	.	11	.	.	.	17	.	.	.	.	.	.	.	.	.	
<i>Teucrium scordium</i> L. subsp. <i>scordioides</i> (Schreb.) Arcang.	.	.	.	.	.	.	.	87	20	.	.	.	.	.	.	.	.	.	.	
<i>Tussilago farfara</i> L.	.	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	22	.	
<i>Valeriana dioica</i> L.	.	.	.	.	.	.	.	.	.	80	100	.	.	.	.	.	.	.	.	
<i>Veronica montana</i> L.	.	17	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Veronica scutellata</i> L.	.	.	.	.	.	.	.	.	61	40	.	.	.	.	.	.	.	.	.	
<i>Veronica serpyllifolia</i> L.	.	6	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Aegopodium podagraria</i> L.	.	.	.	.	.	.	.	.	40	.	.	.	.	.	.	.	.	.	.	
<i>Althaea cannabina</i> L.	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Anthoxanthum odoratum</i> L.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Aristolochia rotunda</i> L.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Asplenium onopteris</i> L.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Athyrium filix-femina</i> (L.) Roth	.	.	.	.	.	.	.	.	.	60	.	.	.	.	.	.	.	.	.	
<i>Berula erecta</i> (Huds.) Coville	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	.	.	.	.	
<i>Bidens frondosa</i> L.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Blackstonia perfoliata</i> (L.) Huds.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Brachypodium rupestre</i> (Host) Roem. & Schult.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	55	.	
<i>Cardamine pratensis</i> L.	.	.	.	.	.	.	.	100	.	.	.	.	.	.	.	.	.	.	.	
<i>Carex canescens</i> L.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Carex caryophyllea</i> Latourr.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Carex flava</i> L.	.	.	.	.	.	.	.	.	50	.	.	.	.	.	.	.	.	.	.	
<i>Carex punctata</i> Gaudin	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Carex strigosa</i> Huds.	.	.	.	22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Carex viridula</i> Michx.	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Centaurium pulchellum</i> (Sw.) Druce subsp. <i>pulchellum</i>	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Centaurium tenuiflorum</i> (Hoffmanns. & Link) Fritsch	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Cerastium semidecandrum</i> L.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Euphorbia peplis</i> L.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Circaeaa lutetiana</i> L. subsp. <i>lutetiana</i>	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Clematis flammula</i> L.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Crepis bellidifolia</i> Loisel.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Silene baccifera</i> (L.) Durande	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17	.	.	.	.	
<i>Cyclamen hederifolium</i> Aiton	.	.	.	.	.	.	.	.	.	.	.	.	.	.	43	.	.	.	.	
<i>Elymus repens</i> (L.) Gould subsp. <i>repens</i>	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Equisetum arvense</i> L.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Euphorbia peplis</i> L.	.	22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Fallopia convolvulus</i> (L.) Å.Löve	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Fragaria vesca</i> L. subsp. <i>vesca</i>	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Galium debile</i> Desv.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Galium rotundifolium</i> L. subsp. <i>rotundifolium</i>	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Geranium purpureum</i> Vill.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Geranium robertianum</i> L.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Geranium sylvaticum</i> L.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Hypochaeris glabra</i> L.	.	.	.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Isolepis setacea</i> (L.) R.Br.	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Jacobsaea erucifolia</i> (L.) G.Gaertn., B.Mey. & Scherb.	.	.	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Juncus conglomeratus</i> L.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Lonicera japonica</i> Thunb.	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Lonicera etrusca</i> Santi	.	.	.	.	.	.	.	.	.	.	.	67	.	.	.	.	.	.	.	

**Table 4.** Continuation.

Column n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Association abbreviation	Lim-Fx1	Lim-Fx2	Lim-Fx3	Lim-Fx4	Lim-Fx5	Lim-Fx6	Cla-Fx1	Cla-Fx2	Cla-Fx3	Leu-Fx1	Leu-Fx2	Val-Fx	Crem-Fx1	Crem-Fx2	Crem-Fx3	Crem-Fx4	Lys-Fx	Rub-Fx	Rub-Ulm	Sal-Fx
<i>Frangulo-Fraxinion, Alnetalia, Alnetea, Magnocaricion elatae</i> species n.	14	8	9	10	4	8	16	8	12	19	13	14	0	3	2	1	5	1	2	0
<i>Carici-Fraxinion, Populetalia, Alno-Populetea</i> species n.	5	6	7	8	6	5	4	2	2	3	4	2	11	18	16	5	14	11	6	7
<i>Lotus corniculatus</i> L. subsp. <i>alpinus</i> (DC.) Rothm.	·	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Mentha x verticillata</i> L.	·	·	·	·	·	·	·	·	·	83	·	·	·	·	·	·	·	·	·	·
<i>Moehringia trinervia</i> (L.) Clairv.	·	·	29	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Myosotis laxa</i> Lehm. subsp. <i>cespitosa</i> (Schultz) Hyl. ex Nordh.	·	11	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Myosotis scorpioides</i> L. subsp. <i>scorpioides</i>	·	·	·	·	·	·	·	·	·	96	·	·	·	·	·	·	·	·	·	·
<i>Myrtus communis</i> L.	·	·	·	30	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Phelipanche purpurea</i> (Jacq.) Soják	·	6	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Parietaria officinalis</i> L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	50	·	·	·	·
<i>Persicaria lapathifolia</i> (L.) Delarbre subsp. <i>lapathifolia</i>	·	·	57	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Phillyrea angustifolia</i> L.	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Phytolacca americana</i> L.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Pinus pinaster</i> Aiton subsp. <i>pinaster</i>	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Platanthera chlorantha</i> (Custer) Rchb.	·	·	·	30	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Platanus</i> sp.	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Poa annua</i> L.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Poa balbisii</i> Parl.	·	6	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Potentilla sterilis</i> (L.) Garcke	20	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Pulicaria dysenterica</i> (L.) Bernh.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Pyracantha coccinea</i> M.Roem.	·	·	·	·	·	11	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Ranunculus flammula</i> L.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Ranunculus</i> sp.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Rorippa sylvestris</i> (L.) Besser subsp. <i>sylvestris</i>	·	·	·	·	·	·	·	·	·	43	·	·	·	·	·	·	·	·	·	·
<i>Rosa canina</i> L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	44	·
<i>Rubus</i> sp.	·	·	12	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Salix apennina</i> A.K.Skvortsov	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	100	·	·	·	·
<i>Lolium arundinaceum</i> (Schreb.) Darbysh. subsp. <i>arundinaceum</i>	6	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Schenkia spicata</i> (L.) G.Mans.	·	6	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Scirpoides holoschoenus</i> (L.) Soják	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Scrophularia nodosa</i> L.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Lychnis flos-cuculi</i> L. subsp. <i>flos-cuculi</i>	·	29	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Betonica officinalis</i> L.	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Succisa pratensis</i> Moench	·	·	·	·	·	·	·	·	·	60	·	·	·	·	·	·	·	·	·	·
<i>Symphytum squatum</i> (Spreng.) G.L.Nesom	·	·	·	·	33	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Taxodium distichum</i> (L.) Rich.	·	·	·	18	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Thalictrum flavum</i> L.	·	·	·	·	·	·	·	·	·	43	·	·	·	·	·	·	·	·	·	·
<i>Thalictrum lucidum</i> L.	·	·	·	·	·	10	·	·	·	·	83	·	·	·	·	·	·	·	·	·
<i>Trifolium fragiferum</i> L. subsp. <i>fragiferum</i>	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Triglochin barrelieri</i> Loisel.	·	·	·	20	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Galatella pannonica</i> (Jacq.) Galasso, Bartolucci & Ardenghi	·	·	·	10	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Veronica anagallis-aquatica</i> L. subsp. <i>anagallis-aquatica</i>	·	·	·	·	·	·	·	·	57	·	·	·	·	·	·	·	·	·	·	·
<i>Veronica chamaedrys</i> L. subsp. <i>chamaedrys</i>	·	·	·	20	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
<i>Veronica officinalis</i> L.	·	·	14	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

3. *lauretosum nobilis subass. nova*, Rels 54–57 in Suppl. material 2: Table S1; *holotypus* relevé 55 in Suppl. material 2: Table S1. This subassociation occurs in more thermophil

the woods of the *Crataego-Quercion* alliance (*Quercoco-Fagetea*). This evidence is highlighted by several subnitrophilous species such as *Sambucus nigra*, *Chaerophyllum temulum*, *Geum urbanum*, *Arctium lappa*, *Galium aparine* and less water-demanding species like *Fraxinus ornus* and *Quercus cerris*. In this subassociation we found a decrease in the number of species belonging to the class *Alnetea* and an increase for the species of the class *Alno-Populetea*.

**ASPARAGO TENUIFOLII-CARPINETUM BETULI** Arrigoni 1997. *Holotypus*: Table 2, rel. 90 in Arrigoni (1997) – Mesophyloous floodplain forests dominated by *Carpinus betulus* (Table 5)

**Diagnostic species:** *Carpinus betulus*, *Anemonoides nemorosa*, *Asparagus tenuifolius*, *Corylus avellana*, *Crataegus laevigata*, *Polygonatum multiflorum*, *Dioscorea communis*, *Ilex aquifolium*, *Lonicera etrusca*, *Rubus hirtus*, *Sorbus torminalis*, *Asarum europaeum*.

**Dominant trees:** *Carpinus betulus*, *Quercus robur*.

**Ecology and Chorology:** Mesophilous woods can be found in sites where submersion is very occasional. This is a community with a more evident C-European character, highlighted by the lowest percentage of Mediterranean species and the highest percentages of European and European-Mediterranean ones (Fig. 2). According to the EIV analysis (Fig. 1), the woods dominated by *Carpinus betulus* show ecological requirements similar to those of *Quercus robur* communities, except for a slightly prefer-

ence for lower temperature.

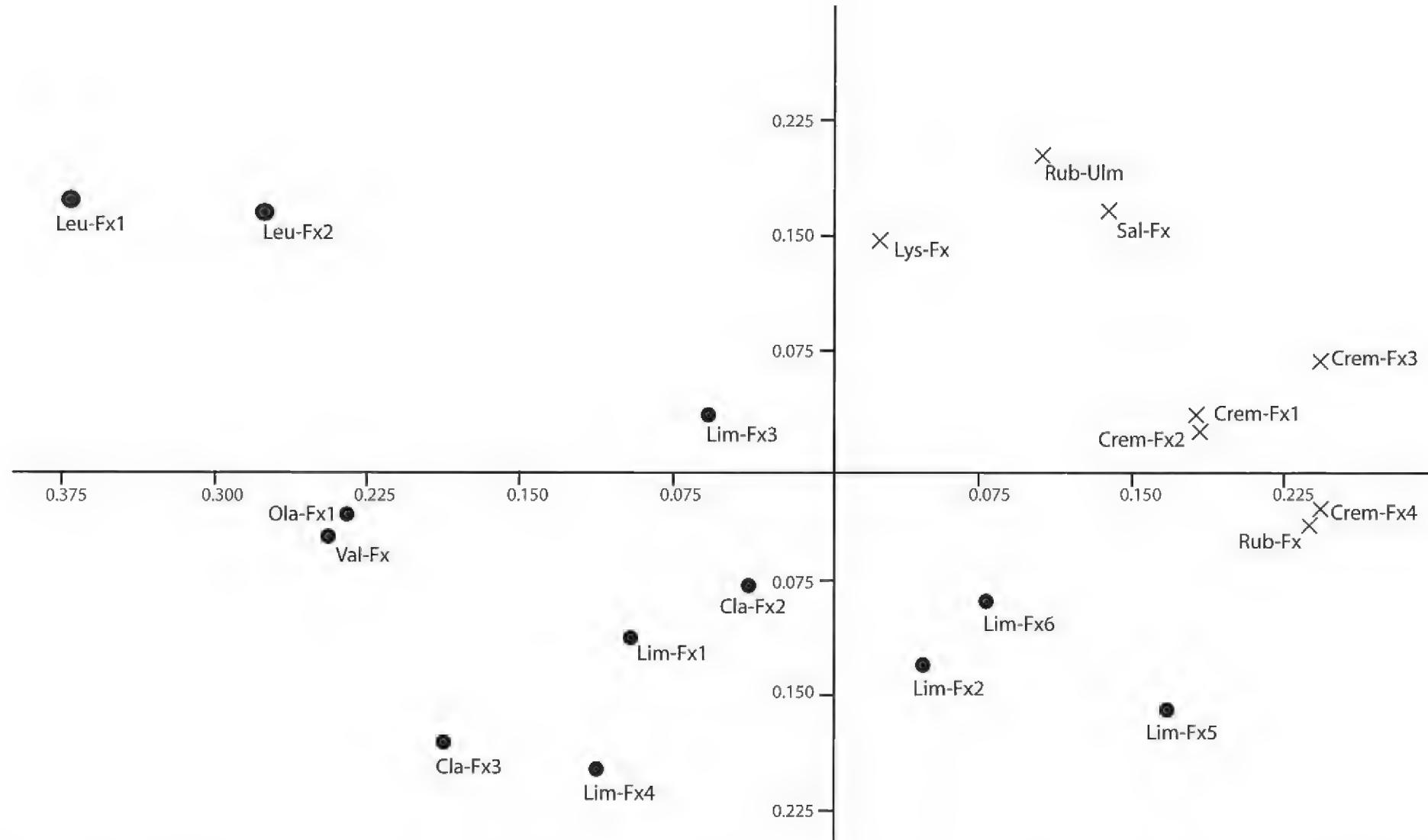
**Distribution in Tuscany (Fig. 3):** Cerbaie (Arrigoni 1997, 1998).

**Syntaxonomy:** The association *Asparago tenuifolii-Carpinetum betulii* was described by Arrigoni (1997) for the Cerbaie hills, in north-western Tuscany. Arrigoni (1997; Table 2) reported two different associations: *Polygonato multiflori-Quercetum roboris* Sartori 1984 (Sartori 1984; Brullo and Spampinato 1999) and the new association *Asparago tenuifolii-Carpinetum betulii* (Arrigoni 1997). According to our analysis, and also to some important floristic differences (i.e. the lack of *Convallaria majalis*, diagnostic for *Polygonato-Quercetum roboris*, see Brullo and Spampinato 1999), the totality of the relevés in question can be assigned to the association *Asparago tenuifolii-Carpinetum betulii* and the association *Polygonato-Quercetum roboris* is to be excluded from Tuscany. These forests were found in the small plain sites of the lower parts of the Cerbaie hills. This association was assigned to the *Crataego-Quercion* and could be considered the wettest association of this alliance.

**PERIPLOCO GRAECAE-ULMETUM MINORIS** Vagge et Biondi, 1999. *Holotypus*: table 20, rel. 3 in Vagge and Biondi (1999) – Elm interdune groves (Table 6)

**Diagnostic species:** *Ulmus minor*, *Rhamnus alaternus*, *Smilax aspera*, *Rosa sempervirens*, *Rubia peregrina*, *Phillyrea angustifolia*, *Periploca graeca*, *Asparagus acutifolius*.

**Dominant tree:** *Ulmus minor*.



**Figure 4.** NMDS ordination scatterplot for the synthetic tables of the Italian woods dominated by *Fraxinus angustifolia* subsp. *oxycarpa*. Crem-Fx: *Carici remotae-Fraxinetum*; Cla-Fx: *Cladio marisci-Fraxinetum*; Sal-Fx: *Salici apenninae-Fraxinetum*; Rub-Fx: *Rubo caesi-Fraxinetum*; Lys-Fx: *Lysimachio-Fraxinetum*; Leu-Fx: *Leucojo verni-Fraxinetum*; Val-Fx: *Valeriano-Fraxinetum*; Lim-Fx: *Limnirido pseudacori-Fraxinetum*. Data from Tables 1–2 by Poldini and Sburlino (2018) with the exception of Lim-Fx, data from this paper.

**Table 5.** *Asparago tenuifolii-Carpinetum betulii* Arrigoni 1997. Species reported by the original authors as diagnostic are written in italics.

Rel. n°		1	2	3
Phi	<b><i>Asparago tenuifolii-Carpinetum betulii</i></b>			
87	<i>Carpinus betulus</i> L.	4	4	4
97	<i>Anemonoides nemorosa</i> (L.) Holub	2	2	+
94	<i>Corylus avellana</i> L.	+	1	1
99.2	<i>Ilex aquifolium</i> L.	+	+	r
91.7	<i>Malus sylvestris</i> (L.) Mill.	1	1	+
92.2	<i>Lonicera etrusca</i> Santi	+	+	1
99.2	<i>Polygonatum multiflorum</i> (L.) All.	+	r	1
78.1	<i>Asparagus tenuifolius</i> Lam.	·	+	+
73.5	<i>Crataegus laevigata</i> (Poir.) DC.	+	r	·
61.9	<i>Dioscorea communis</i> (L.) Caddick & Wilkin	·	r	+
77.1	<i>Festuca heterophylla</i> Lam.	+	r	·
76.2	<i>Mespilus germanica</i> L.	+	r	·
75.3	<i>Rubus hirtus</i> Waldst. & Kit. group	+	+	·
75.2	<i>Sorbus torminalis</i> (L.) Crantz	r	r	·
	<i>Asarum europaeum</i> L.	r	·	·
	<b><i>Crataego-Quercion, Quercetalia pubescenti-petraeae, Querco-Fagetea</i></b>			
	<i>Physospermum cornubiense</i> (L.) DC.	+	r	r
	<i>Quercus robur</i> L. subsp. <i>robur</i>	4	4	4
	<i>Hedera helix</i> L. subsp. <i>helix</i>	2	2	3
	<i>Euonymus europaeus</i> L.	·	r	+
	<i>Viola reichenbachiana</i> Jord. ex Boreau	r	r	·
	<i>Luzula pilosa</i> (L.) Willd.	+	+	·
	<i>Prunus avium</i> L. subsp. <i>avium</i>	·	·	r
	<i>Crataegus monogyna</i> Jacq.	·	·	1
	<i>Acer campestre</i> L.	·	+	·
	<i>Pteridium aquilinum</i> (L.) Kuhn subsp. <i>aquilinum</i>	·	·	r
	<b>Other species</b>			
	<i>Ruscus aculeatus</i> L.	1	1	1
	<i>Arisarum proboscideum</i> (L.) Savi	+	·	r
	<i>Alnus glutinosa</i> (L.) Gaertn.	·	2	1
	<i>Lathraea clandestina</i> L.	+	r	·
	<i>Arum italicum</i> Mill. subsp. <i>italicum</i>	·	·	r
	<i>Pyrus communis</i> L.	·	·	2
	<i>Frangula alnus</i> Mill. subsp. <i>alnus</i>	+	·	·
	<i>Myosotis sicula</i> Guss.	·	r	·
	<i>Cornus sanguinea</i> L.	·	·	+
	<i>Dactylis glomerata</i> L. s.l.	·	r	·
	<i>Quercus petraea</i> (Matt.) Liebl. subsp. <i>petraea</i>	1	·	·
	<i>Castanea sativa</i> Mill.	r	·	·
	<i>Ligustrum lucidum</i> W.T.Aiton	·	·	1
	<i>Euphorbia dulcis</i> L.	·	·	r
	<i>Holcus mollis</i> L. subsp. <i>mollis</i>	·	r	·
	<i>Loncomelos pyramidale</i> (L.) Raf.	·	·	r
	<i>Neottia nidus-avis</i> (L.) Rich.	·	·	r
	<i>Viola riviniana</i> Rchb.	·	·	r

**Ecology and Chorology:** Recently established woods, located on wet clay soils rich in nutrients. This is the most typical Mediterranean vegetation type among those investigated: here we found the highest percentage of Mediterranean species (Figure 2). According to the EIV analysis (Fig. 1), the groves with *Ulmus minor* show a negative relation to Soil Moisture (U).

**Distribution in Tuscany (Fig. 3):** This vegetation type was found in the coastal systems of Tuscany. Tenuta di Migliarino (Vagge and Biondi 1999; Sani et al. 2011), Tombolo di Tirrenia (AA.VV. 2005), Tombolo di Cecina (Vagge and Biondi 1999).

**Syntaxonomy:** *Ulmus minor* groves of Tuscany were referred to the association *Periploco graecae-Ulmetum minoris* Vagge and Biondi 1999), described for the coastal areas of Tuscany from Migliarino to Cecina (Vagge and Biondi 1999).

**DIOSCOREO COMMUNIS-POPULETUM NIGRAE** Poldini et Vidali in Poldini, Sburlino et Vidali, 2017. **Holotypus:** rel. 1 of Table I of Poldini et Vidali in Poldini, Sburlino et Vidali, 2017 – Riparian wood with poplars and/or willows (Table 7)

**Diagnostic species:** *Populus nigra*, *Salix alba*, *Rubus caesius*, *Xanthium orientale* subsp. *italicum*, *Salix cinerea*, *Humulus lupulus* (phi >40), *Populus alba*, *Ulmus minor*, *Galega officinalis*, *Pulicaria disenterica* (phi > 30).

**Dominant trees:** *Populus* sp.pl., *Salix alba*.

**Ecology and Chorology:** This vegetation encompasses the woods that are located along riparian areas, placed in sites where the influence of rivers is marginal, like abandoned meanders or alluvial sectors in sedimentation. In the wet season, these communities are subject to even prolonged periods of submersion. This is a heterogeneous vegetation type, in which patches dominated by trees like poplars were found mixed with tall willow trees and shrubs. This vegetation is characterized by chorotypes with wide distribution (Eurosibiric, Cosmopolitan/Circumboreal) (Fig. 2). Unfortunately, from the conservation point of view, these vegetation types are rich in alien species. According to the EIV analysis (Fig. 1), the woods dominated by *Populus* sp.pl., and *Salix alba* are positively related to N (Nutrient).

**Distribution in Tuscany (Fig. 3):** Macchia Lucchese (Arrigoni 1990), Selva di San Rossore (Gellini et al. 1986), Lago di Montepulciano and Lago di Chiusi (Lastrucci et al. 2014), Lago di Santa Luce (Bertacchi et al. 2005), Lago di San Floriano, Piana di Firenze and Valdarno superiore (Viciani and Raffaelli 2003). Many other sites with this vegetation type are probably present in other parts of Tuscany in addition to those reported here.

**Syntaxonomy:** In the past, similar coenoses have been attributed by many Italian authors (e.g. Pedrotti and Gafta 1996; Venanzoni and Gigante 2000; Pirone et al. 2003) to *Populetum albae* (Br.-Bl. 1931) Tchou or to *Salici-Populetum nigrae* (Tüxen 1931) Meyer-Drees 1936, mainly in relation to the dominant species. Very recently, some authors (Poldini et al., 2017; 2020) faced this issue and found that many *Salici-Populetum nigrae* communities sensu Auct. Ital. can be attributed to a recent established association named *Dioscoreo communis-Populetum nigrae*, which encompasses typical aspects dominated by *Salix alba* and *Populus nigra*, together with aspects dominated by *Populus alba*. *Dioscoreo communis-Populetum nigrae* is attributed to a new alliance, named *Dioscoreo communis-Populion nigrae*. Our relevés belonging to group 6 (Table 7) are not easy to classify, due to their heterogeneous floristic composition (common in these coenoses) but can be provisionally attributed to this syntaxon. The relevés 1–7, dominated by *Populus alba*, can be attributed

**Table 6.** *Periploco graecae-Ulmetum minoris* Vagge et Biondi, 1999. Species reported by the original authors as diagnostic are written in italics.

Rel. n°		1	2	3	4	5	6	7
Phi	<b><i>Periploco graecae-Ulmetum minoris</i></b>							
	<i>Ulmus minor</i> Mill. subsp. <i>minor</i>	4	5	5	4	5	4	5
	<i>Periploco graeca</i> L.	·	3	+	·	·	3	2
82.2	<i>Rhamnus alaternus</i> L. subsp. <i>alaternus</i>	r	·	+	r	1	·	+
69.5	<i>Smilax aspera</i> L.	r	1	+	+	·	2	1
68	<i>Rubia peregrina</i> L.	+	1		+	2	1	1
66.3	<i>Rosa sempervirens</i> L.	·	·	1	+	1	·	+
59.2	<i>Phillyrea angustifolia</i> L.	·	·	·	2	1	·	1
	<b><i>Lauro-Ulmion, Rubio-Ulmetalia, Alno-Populetea</i></b>							
	<i>Rubus ulmifolius</i> Schott	3	3	·	+	1	3	2
	<i>Hedera helix</i> L. subsp. <i>helix</i>	r	3	·	·	4	2	2
	<i>Brachypodium sylvaticum</i> (Huds.) P.Beauv. subsp. <i>sylvaticum</i>	+	·	·	+	3	·	+
	<i>Fraxinus angustifolia</i> Vahl subsp. <i>oxycarpa</i> (M.Bieb. ex Willd.) Franco & Rocha Afonso	3	·	·	·	·	·	+
	<i>Alnus glutinosa</i> (L.) Gaertn.	·	1	·	·	·	·	·
	<i>Euonymus europaeus</i> L.	·	·	·	·	1	·	·
	<i>Laurus nobilis</i> L.	·	·	·	·	1	·	·
	<i>Dioscorea communis</i> (L.) Caddick & Wilkin	·	·	·	+	·	·	·
	<i>Chamaeiris foetidissima</i> (L.) Medik.	·	·	·	r	·	·	·
	<b><i>Quercetea ilicis</i></b>							
	<i>Asparagus acutifolius</i> L.	·	·	·	·	+	·	1
	<i>Ruscus aculeatus</i> L.	·	·	·	·	+	·	+
	<i>Pistacia lentiscus</i> L.	·	·	·	3	+	·	·
	<i>Viola alba</i> Besser subsp. <i>dehnhardtii</i> (Ten.) W. Becker	r	·	·	·	·	·	·
	<i>Myrtus communis</i> L.	·	·	·	+	·	·	·
	<i>Quercus ilex</i> L. subsp. <i>ilex</i>	·	·	·	·	1	·	·
	<b><i>Other species</i></b>							
	<i>Prunus spinosa</i> L. subsp. <i>spinosa</i>	r	·	1	·	+	·	+
	<i>Prunella vulgaris</i> L. subsp. <i>vulgaris</i>	+	·	·	r	·	·	·
	<i>Carex otrubae</i> Podp.	+	·	·	+	·	·	·
	<i>Robinia pseudoacacia</i> L.	·	2	·	·	·	2	·
	<i>Phragmites australis</i> (Cav.) Trin. ex Steud. subsp. <i>australis</i>	·	+	1	·	·	·	·
	<i>Pinus pinea</i> L.	·	·	·	·	·	·	5
	<i>Lonicera etrusca</i> Santi	·	·	·	·	·	·	+
	<i>Crataegus monogyna</i> Jacq.	·	·	·	·	+	·	·
	<i>Ligustrum vulgare</i> L.	·	·	·	·	+	·	·
	<i>Potentilla reptans</i> L.	r	·	·	·	·	·	·
	<i>Rumex sanguineus</i> L.	r	·	·	·	·	·	·
	<i>Poa trivialis</i> L.	2	·	·	·	·	·	·
	<i>Carex distans</i> L.	r	·	·	·	·	·	·
	<i>Carex divulsa</i> Stokes	2	·	·	·	·	·	·
	<i>Oenanthe lachenalii</i> C.C.Gmel.	r	·	·	·	·	·	·
	<i>Plantago major</i> L.	r	·	·	·	·	·	·
	<i>Pyrus communis</i> L.	·	·	·	·	+	·	·
	<i>Vitis vinifera</i> L. subsp. <i>sylvestris</i> (C.C. Gmel.) Hegi	·	+	·	·	·	·	·
	<i>Mentha suaveolens</i> Ehrh.	r	·	·	·	·	·	·
	<i>Jacobaea erratica</i> (Bertol.) Fourr.	r	·	·	·	·	·	·
	<i>Phillyrea latifolia</i> L.	r	·	·	·	·	·	·
	<i>Rosa</i> sp.	r	·	·	·	·	·	·
	<i>Trifolium pratense</i> L. subsp. <i>pratense</i>	r	·	·	·	·	·	·
	<i>Catapodium rigidum</i> (L.) C.E.Hubb. s.l.	r	·	·	·	·	·	·
	<i>Limonium narbonense</i> Mill.	·	·	+	·	·	·	·
	<i>Sison amomum</i> L.	+	·	·	·	·	·	·
	<i>Tamarix</i> sp.	·	·	3	·	·	·	·
	<i>Taraxacum</i> sp.	r	·	·	·	·	·	·
	<i>Quercus pubescens</i> Willd.	·	·	·	·	·	·	+

to *Dioscoreo communis-Populetum nigrae populetosum albae*, while the relevés 8–18, dominated by *Salix alba* and *Populus nigra*, to the subass. *typicum*. These communities are floristically well characterized only for the tree layer, and from the successional and ecological points of view.

The spatial distribution scheme of these associations

in the mosaic of the floodplain vegetation of Tuscany is shown in Figs 1 and 3 of Gellini et al. (1986). We add to these the groves dominated by *Ulmus minor* that can be found in Mediterranean coastal areas of central-southern Tuscany. Furthermore, we added the poplar and willow vegetation that, with the only exception of coastal areas,

**Table 7.** *Dioscoreo communis-Populion nigrae* Poldini et Vidali in Poldini, Sburlino et Vidali, 2017. Rels 1–7: *Dioscoreo communis-Populetum nigrae* Poldini et Vidali in Poldini, Sburlino ex Vidali, 2017 *populetoum albae* (Biondi, Vagge, Baldoni ex Taffetani, 1999) Poldini, Vidali ex Castello, 2020; rels 8–18: *Dioscoreo communis-Populetum nigrae* Poldini et Vidali in Poldini, Sburlino ex Vidali, 2017 *typicum*.

**Table 7.** Continuation.

Phi	Rel. n.	1	2	3	4	5	6	7	8	9	11	12	10	13	14	15	16	17	18
<i>Artemisia vulgaris</i> L.		.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	
<i>Cruciata laevipes</i> Opiz		.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	
<i>Daucus carota</i> L. s.l.		.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	
<i>Equisetum telmateia</i> Ehrh.	1	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	
<i>Erigeron canadensis</i> L.		.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	
<i>Jacobsaea aquatica</i> (Hill) G.Gaertn., B.Mey. & Scherb.		.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	
<i>Juncus inflexus</i> L. subsp. <i>inflexus</i>		.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	
<i>Ligustrum ovalifolium</i> Hassk.	2	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Phalaris arundinacea</i> L. subsp. <i>arundinacea</i>		.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.	
<i>Plantago major</i> L.		.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	
<i>Potentilla reptans</i> L.		.	.	.	.	.	.	.	r	.	+	.	.	.	.	.	.	.	
<i>Quercus robur</i> L. subsp. <i>robur</i>	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Ruscus aculeatus</i> L.		.	2	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	
<i>Sambucus ebulus</i> L.		.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	
<i>Teucrium scordium</i> L. s.l.		.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	
<i>Torilis japonica</i> (Houtt.) DC.		.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	
<i>Typha latifolia</i> L.		.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	
<i>Verbena officinalis</i> L.		.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	.	
<i>Carex riparia</i> Curtis		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	
<i>Artemisia verlotiorum</i> Lamotte		.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	
<i>Arundo donax</i> L.		.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	
<i>Brachypodium rupestre</i> (Host) Roem. & Schult.		.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	
<i>Bromus arvensis</i> L.		.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	
<i>Convolvulus sepium</i> L.		.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Convolvulus arvensis</i> L.		.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	
<i>Ficus carica</i> L.		.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Ligustrum vulgare</i> L.		.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Paspalum distichum</i> L.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	
<i>Thalictrum lucidum</i> L.		.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	
<i>Atriplex prostrata</i> Boucher ex DC.		.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	
<i>Lolium perenne</i> L.		.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	
<i>Lonicera caprifolium</i> L.		.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Lotus corniculatus</i> L. s.l.		.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	
<i>Mentha pulegium</i> L. subsp. <i>pulegium</i>		.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	
<i>Mentha suaveolens</i> Ehrh.		.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Quercus cerris</i> L.		.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	
<i>Quercus ilex</i> L. subsp. <i>ilex</i>		.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Rubia peregrina</i> L.		.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Rubus canescens</i> DC.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Thalictrum flavum</i> L.		.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	

was also found in the areas around the large lakes of Chiusi and Montepulciano (Lastrucci et al. 2014).

## Nature conservation remarks

Our results clarified the phytosociological classification of lowland woody communities in Tuscany, that is crucial to attribute them to the appropriate habitat type of conservation concern, listed in the Directive 92/43/EEC. The coenoses here described represent, in general, threatened plant communities that deserve strict conservation measures. Accordingly, based on Biondi et al. (2009, 2012) and the European Commission (2013), the floodplain woods of Tuscany can be referred to Natura 2000 habitats of Community interest as follows.

– *Alnus glutinosa* and *Fraxinus angustifolia* subsp. *oxycarpa* dominated communities (*Hydrocotylo vulgaris-Alnetum glutinosae*; *Limnirido pseudacori-Fraxine-*

*tum oxycarpae*): habitat 91E0\* – Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*).

- *Quercus robur* and *Ulmus minor* dominated communities (*Fraxino-Quercetum roboris*; *Periploco graecae-Ulmetum minoris*): habitat 91F0 – Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*); when there is a codominance of *Carpinus betulus*, the habitat 9160 – Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli* – can be used.
- *Carpinus betulus* dominated communities (*Asparago tenuifolii-Carpinetum betuli*): habitat 9160 – Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*.
- *Populus* spp. and *Salix* spp. dominated communities (*Dioscoreo communis-Populetum nigrae*): habitat 92A0 – *Salix alba* and *Populus alba* galleries.

## Syntaxonomic scheme

ALNETEA GLUTINOSAE Br.-Bl. et Tüxen ex Westhoff, Dijk et Passchier, 1946

ALNETALIA GLUTINOSAE Tx. 1937

**Alnion glutinosae** Malcuit, 1929

*Hydrocotylo vulgaris-Alnetum glutinosae* Gellini, Pedrotti et Venanzoni, 1986

**Frangulo alni-Fraxinion oxycarpae** Poldini, Sburlino et Venanzoni in Biondi, Allegrezza, Casavecchia, Galderzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge et Venanzoni, 2015  
*Limnirido pseudacori-Fraxinetum oxycarpae* Gennai, Gabellini, Viciani, Venanzoni, Dell'Olmo, Giunti, Lucchesi, Monacci, Mugnai et Foggi *ass. nova*

ALNO GLUTINOSAE-POPULETEA ALBAE P. Fukarek et Fabijanić, 1968

POPULETALIA ALBAE Br.-Bl. ex Tchou, 1948

**Carici remotae-Fraxinion oxycarpae** Pedrotti ex Pedrotti, Biondi, Allegrezza et Casavecchia in Biondi, Allegrezza, Casavecchia, Galderzi, Gasparri, Pesaresi, Vagge et Blasi, 2014

*Fraxino oxycarpae-Quercetum roboris* Gellini, Pedrotti et Venanzoni, 1986

*typicum*

*carpinetosum betuli* Gellini, Pedrotti et Venanzoni, 1986 ex Gennai, Gabellini, Viciani, Venanzoni, Dell'Olmo, Giunti, Lucchesi, Monacci, Mugnai et Foggi *subass. nova*  
*lauretosum nobilis* Gennai, Gabellini, Viciani, Venanzoni, Dell'Olmo, Giunti, Lucchesi, Monacci, Mugnai et Foggi *subass. nova*

*sambucetosum nigrae* Gennai, Gabellini, Viciani, Venanzoni, Dell'Olmo, Giunti, Lucchesi, Monacci, Mugnai et Foggi *subass. nova*

**Dioscoreo communis-Populion nigrae** Poldini et Vidali in Poldini, Sburlino et Vidali, 2017

*Dioscoreo communis-Populetum nigrae* Poldini et Vidali in Poldini, Sburlino et Vidali, 2017 *typicum*

*Dioscoreo communis-Populetum nigrae* Poldini et Vidali in Poldini, Sburlino et Vidali, 2017 *populetoum albae* (Biondi, Vagge, Baldoni et Taffetani, 1999) Poldini, Vidali et Castello, 2020

RUBIO PEREGRINAE-ULMETALIA MINORIS Biondi, Casavecchia, Gasparri et Pesaresi in Allegrezza, Casavecchia, Galderzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge et Venanzoni, 2015

**Lauro nobilis-Ulmion minoris** Biondi, Casavecchia, Gasparri et Pesaresi in Allegrezza, Casavecchia, Galderzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge et Venanzoni, 2015

*Periploco graecae-Ulmetum minoris* Vagge et Biondi, 1999

QUERCO ROBORIS-FAGETEA SYLVATICA Br.-Bl. et Vlieger in Vlieger, 1937

QUERCETALIA PUBESCENTIS Klika, 1933

**Crataego laevigatae-Quercion cerridis** Arrigoni, 1997

*Asparago tenuifolii-Carpinetum betuli* Arrigoni, 1997

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## Appendices

### Appendix I – Literature concerning the floodplain vegetation of Tuscany from which we selected the relevés

AA.VV., 2005 – Piano di Gestione Forestale della “Tenuta di Tombolo” di proprietà del Comune di Pisa. Periodo di validità 2005 – 2014. D.R.E.A.M. Italia. Poppi (AR). Relazione tecnica, 193 pagine.

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(2004); Rels. 33, 34, 35, 39, 40 = rels. 32, 80, 83, 29, 67 from Tab. 11 in Sani A. & al. (2011); Rels. 6, 16, 17, 18, 19, 20, 21, 22, 23, 28, 29, 31 = rels. 18, 9, 42, 49, 63, 65, 68, 85, 95, 33, 34, 47 from Tab. 10 in Sani A. & al. (2011); Rels. 1, 2, 3, 30, 47 = unpublished rels. 10, 11, 12, 35 by Gabellini A. in Piano di Gestione Forestale della “Tenuta di Tombolo”; Rels. 32, 36, 37, 38, 41, 42, 43, 44, 46 = rels. 80, 91, 103, 124, 79, 97, 123, 81, 94 from Tab. 15 in Arrigoni P.V. (1990); Rels. 11, 15 = rels. X023, X026 from Tab. 16 in Foggi & al. (2000); Rels. 4, 5 = rels. 3, 36 from Tab. 8 in Coaro E. (1987); Rels. 7, 8, 10, 12, 13, 14 = rels. 3, 84, 53, 55, 20, 99 from Tab. 3. in Tomei & al. (2004); Rels. 9, 24, 25, 26, 27 = rels. 4, 2, 6, 5, 3 from Tab. 3. in Gellini & al. (1986).

Suppl. material 2: Table S1 – Rels. 34, 36, 37, 38, 39, 40, 41, 42, 43, 47, 49, 50 = rels. 1, 16, 11, 15, 12, 14, 10, 22, 9, 18, 20, 19 from Tab. 3 in Gellini & al. (1986); Rels. 7, 51, 88, 39, 56, 6, 2, 11, 17, 1, 9, 34, 33, 14, 43, 4 = rels. 6, 49, 43, 14, 17, 2, 11, 7, 1, 33, 39, 56, 51, 88, 34 from Tab. 1 in Tomei & al. (2004); Rels. 33, 44 = rels. 14, 42 from Tab. 3 in Tomei & al. (2004); Rels. 9, 25, 26, 32, 47 = rels. 18, 12, 20, 10, 30 from Tab. 4 in Coaro E. (1987); Rels. 39 = rels. 42 from Tab. 5 in Coaro E. (1987); Rels. 35, 36, 37, 38, 39 = rels. 11, 13, 21, 33, 2 from Tab. 8 in Coaro E. (1987); Rels. 6, 51, 52 = rels. 8, 44, 36 from Tab. 8 in Sani A. & al. (2011); Rels. 54, 55, 57 = rels. 39, 43, 40 from Tab. 9 in Sani A. & al. (2011); Rels. 18, 19, 22, 23, 56 = rels. 9, 13, 7, 8, 6 in patch n. 255, patch n. 257, patch n. 262, patch n. 262, patch n. 262 in AA.VV. (2005); Rels. 69, 75, 61, 62 = rels. unpublished in Gabellini A. & al. (2018); Rels. 7, 13, 14 = rels. 1, 4, 10 from Tab. 1 in Bertacchi A. & Lombardi T. (2016); Rels. 15, 31 = rels. 17, 4 from Tab. 2 in Tomei P.E. & Cenni M. (1986); Rels. 17 = rels. 53 from Tab. 15 in Arrigoni P.V. (1990); Rels. 58, 59, 60, 63, 64, 65, 66, 67, 68, 70, 71 = rels. G007, V003, V004, G008, V002, G001, G009, G010, G006, V001, V005 from Tab. 1 in Gabellini A. & Viciani D. (2012); Rels. 16 = rels. 63 from Tab. 9 in Arrigoni P.V. (1997); Rels. 30 = rels. 94 from Tab. 2 in Arrigoni P.V. (1997).

Table 6 – Rels. 2, 6 = rel. 220, 210 Tab. 20 from Arrigoni P.V. & al. (1985). Rel. 4, 5, 7, 8, 9 = rels. 2, 4, 5, 1, 3 Tab. 20 from Vagge I., Biondi E. (1999).

Table 7 – Rels. 1, 5 unpublished from Gabellini A. & al. (2018). Rels. 10–16 = rels. 7–11, 13, 14 Tab. 10 from Lastrucci L. & al. (2014). Rels. 8, 17 = rels. 9, 4 Tab. 3 from Bertacchi A. & al. (2005). Rels. 7, 18 = rels. 37, 35 unpublished from Gennai M. & Lastrucci L. (2013). Rels. 6 = rels. 8 unpublished from Ferretti G. & Lastrucci L. (2010). Rels. 2, 9 = rels. 59, 126 Tab. 15 from Arrigoni P.V. (1990). Rel. 3 = rel. 5, from AA. VV (2005). Rel. 4 = rel. 30 Tab. 4 from Gellini & al. (1986).

## Appendix II – Correspondence between the relevé numbers in our tables and original bibliographic references

Table 2 – Rels. 4, 5, 6 = rels. 16, 10, 12 in Lastrucci L. & al. (2016); Rels. 1, 11, 21 = rels. 46, 45, 50 from Tab. 12 in Sani A. & al. (2011); Rels. 2, 3, 7, 8, 12 = rels. 144, 32, 54, 109, 142 from Tab. 14 in Arrigoni P.V. (1990); Rels. 9, 13, 18, 23, 24 = rels. 27, 26, 25, 24, 28 from Tab. 1 in Gellini & al. (1986); Rels. 14, 25 = rels. 8, 7 from Tab. 3 in Gellini & al. (1986); Rels. 10, 16, 17, 20 = rels. 21, 57, 59, 63 from Tab. 6 in Tomei & al. (2004); Rels. 15, 22 unpublished in Gabellini A. & al. (2018); Rels. 26, 27, 28, 29, 30 = rels. 73, 74, 75, 76, 84 from Tab. 3 in Arrigoni P.V. (1997).

Table 3 – Rels. 45 = rels. 38 from Tab. 5 in Tomei & al.

Table 2 – *Aegopodium podagraria* L. (22), *Anemonoides nemorosa* (L.) Holub (22), *Aristolochia rotunda* L. s.l. (14, 25), *Athyrium filix-femina* (L.) Roth (15), *Aulacomnium palustre* (Hedw.) Schwägr. (22), *Baldellia ranunculoides* (L.) Parl. (13), *Bidens tripartitus* L. s.l. (22), *Calypogeia*

## Appendix III – Sporadic species

*sphagnicola* (Arn. & Perss.) Warnst. & Loeske (22), *Carex distans* L. (7), *Carex divulsa* Stokes (10), *Carex flacca* Schreb. s.l. (20), *Carex punctata* Gaudin (9), *Carex* sp. (12), *Chamaesyce peplis* (L.) Prokh. (18, 23), *Circaea lutetiana* L. subsp. *lutetiana* (15, 22), *Corylus avellana* L. (15), *Dioscorea communis* (L.) Caddick & Wilkin (15), *Emerus major* Mill. s.l. (4), *Euonymus japonicus* Thunb. (5), *Fallopia convolvulus* (L.) Á. Löve (29), *Galium aparine* L. (29, 4), *Galium debile* Desv. (13, 18), *Galium mollugo* L. subsp. *erectum* Syme (15, 29), *Geum rivale* L. (35), *Geum urbanum* L. (26), *Gratiola fromficinalis* L. (19, 13), *Holcus lanatus* L. (19), *Iris foetidissima* L. (16), *Juncus anceps* La-harpe (12), *Juncus articulatus* L. (13), *Juniperus oxycedrus* L. subsp. *macrocarpa* (Sibth. & Sm.) Neilr. (3), *Ligustrum ovalifolium* Hassk. (15), *Ligustrum sinense* Lour. (5, 6), *Ligustrum vulgare* L. (6, 17), *Lysimachia nummularia* L. (22), *Malus sylvestris* (L.) Mill. (21), *Moehringia trinervia* (L.) Clairv. (18), *Myosotis laxa* Lehm. (27), *Myosotis scorpioides* L. subsp. *scorpioides* (30), *Oenanthe pimpinelloides* L. (15), *Persicaria lapathifolia* (L.) Delarbre subsp. *lapathifolia* (13, 23), *Platanus hispanica* Mill. ex Münchh. (4), *Poa annua* L. (18), *Poa sylvicola* Guss. (15), *Populus canescens* (Aiton) Sm. (4), *Potentilla indica* (Andrews) Th. Wolf (4), *Potentilla sterilis* (L.) Garcke (26), *Prunella laciniata* (L.) L. (30), *Prunella vulgaris* L. subsp. *vulgaris* (9, 14), *Prunus laurocerasus* L. (15), *Prunus* sp. (5), *Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum* (30), *Pyracantha coccinea* M. Roem. (2), *Pyrus communis* L. (26), *Ranunculus flammula* L. (13), *Ranunculus lanuginosus* L. (15, 4), *Ranunculus ophioglossifolius* Vill. (9), *Ranunculus sardous* Crantz subsp. *sardous* (16, 17), *Rhamnus cathartica* L. (2), *Rumex conglomeratus* Murray (15, 22), *Rumex sanguineus* L. (13, 23), *Silene latifolia* Poir. subsp. *alba* (Mill.) Greuter & Burdet (29), *Solanum nigrum* L. (12, 22), *Stellaria aquatica* (L.) Scop. (4), *Stellaria media* (L.) Vill. subsp. *media* (14), *Sympyrum tuberosum* L. subsp. *angustifolium* (A. Kern.) Nyman (29), *Thyselium palustre* (L.) Raf. (19), *Veronica montana* L. (17), *Veronica persica* Poir. (14), *Veronica serpyllifolia* L. subsp. *serpyllifolia* (14, 25), *Vinca minor* L. (15), *Viola reichenbachiana* Jord. ex Boreau (22, 14), *Vitis* sp. (4).

Table 3 – *Ajuga reptans* L. (5), *Alisma lanceolatum* With. (38), *Althaea cannabina* L. (6), *Amorpha fruticosa* L. (28, 31), *Aristolochia rotunda* L. (26), *Asparagus acutifolius* L. (30), *Bidens frondosa* L. (42), *Bidens tripartitus* L. s.l. (47), *Blackstonia perfoliate* (L.) Huds. s.l. (12), *Carex canescens* L. (24), *Carex caryophyllea* Latourr. (10, 14), *Carex divulsa* Stokes (27, 33), *Carex flacca* Schreb. s.l. (10, 30), *Carex strigosa* Huds. (30, 47), *Centaurium pulchellum* (Sw.) Druce subsp. *pulchellum* (12), *Centaurium tenuiflorum* (Hfrommanns. & Link) Fritsch subsp. *tenuiflorum* (14), *Cerastium semidecandrum* L. (45), *Crepis bellidifolia* Loisel. (14), *Dittrichia viscosa* (L.) Greuter s.l. (33; 57), *Elymus repens* (L.) Gould subsp. *repens* (2), *Equisetum arvense* L. subsp. *arvense* (25), *Equisetum telmateja* Ehrh. (10, 12), *Eupatorium cannabinum* L. subsp. *cannabinum* (6), *Fallopia convolvulus* (L.) A. Love (3, 47), *Fraxinus ornus* L. subsp. *ornus* (34), *Galium debile* Desv. (9), *Galium palustre*

L. subsp. *elongatum* (C.Presl) Lange (11), *Geum urbanum* L. (47), *Gratiola fromficinalis* L. (20, 39), *Holcus lanatus* L. (12, 45), *Hypericum androsaemum* L. (26), *Hypericum tetrapterum* Fr. (24), *Isolepis setacea* (L.)R.Br. (28), *Juncus conglomeratus* L. (12), *Lemna minor* L. (15), *Lonicera caprifolium* L. (30), *Lonicera caprifolium* L. (30), *Lotus corniculatus* L. s.l. (4), *Luzula forsteri* (Sm.) DC. (45), *Lysimachia arvensis* (L.) U. Manns & Anderb. s.l. (26), *Lysimachia foemina* (Mill.) U. Manns & Anderb. s.l. (11), *Lythrum hysopifolia* L. (11), *Malus sylvestris* (L.) Mill. (18, 23), *Melica uniflora* Retz. (30), *Moehringia trinervia* (L.) Clairv. (24), *Myosotis laxa* Lehm. (45), *Myosotis sylvatica* Hfromfm. subsp. *sylvatica* (45), *Phytolacca americana* L. (24), *Phalaris arundinacea* L. subsp. *arundinacea* (20), *Phytolacca americana* L. (24), *Pinus pinea* L. (36), *Poa annua* L. (27), *Poa palustris* L. (45), *Poa sterilis* L. (38, 43), *Potentilla sterilis* (L.) Garcke (38, 43), *Pulicaria dysenterica* (L.) Berhn. (25), *Pulicaria odora* (L.) Rchb. (15), *Ranunculus bulbosus* L. subsp. *aleae* (Willk.) Rouy & Foucaud (11), *Ranunculus flammula* L. (24), *Ranunculus ophioglossifolius* Vill. (15), *Ranunculus velutinus* Ten. (4, 3), *Ranunculus* sp. (24), *Rosa sempervirens* L. (30), *Rubia peregrina* L. s.l. (30), *Rubus* sp. (19, 21), *Rumex hydrolapathum* Huds. (33), *Sambucus nigra* L. (25), *Schenkia spicata* (L.) G. Mans. (12), *Scirpoides holoschoenus* (L.) Soják (4), *Scrophularia nodosa* L. (24), *Silene flos-cuculi* (L.) Clairv. (24), *Solanum dulcamara* L. (37), *Thalictrum lucidum* L. (15), *Trifolium fragiferum* L. subsp. *fragiferum* (5), *Triglochin bulbosum* L. subsp. *barrelieri* (Loisel.) Rouy (4), *Triplium pannonicum* (Jacq.) Dobrocz. subsp. *pannonicum* (4), *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica* (1524), *Veronica montana* L. (1), *Veronica serpyllifolia* L. subsp. *serpyllifolia* (24, 27).

Suppl. material 2: Table S1 – *Ailanthus altissima* (Mill.) Swingle (65), *Alliaria petiolata* (M. Bieb.) Cavara & Grande (58), *Amorpha fruticosa* L. (31), *Anemoides nemorosa* (L.) Holub (16, 30), *Anthoxanthum odoratum* L. s.l. (62, 45), *Arisarum proboscideum* (L.) Savi (4), *Asparagus tenuifolius* Lam. (30), *Asperula laevigata* L. (61), *Bellevalia romana* (L.) Sweet (15), *Buglossoides purpurea* (L.) I.M. Johnst. (69), *Calluna vulgaris* (L.) Hull (15), *Carex flacca* Schreb. s.l. (6), *Carex flacca* Schreb. subsp. *flacca* (39, 40), *Carex leporina* L. (37), *Carex pallescens* L. (41), *Carex punctata* Gaudin (36), *Carex riparia* Curtis (43), *Castanea sativa* Mill. (62), *Cerastium brachypetalum* Desp. ex Pers. s.l. (74), *Chamaesyce peplis* (L.) Prokh. (36), *Clematis flammula* L. (3), *Clinopodium nepeta* (L.) Kuntze s.l. (11), *Clinopodium vulgare* L. s.l. (71), *Clinopodium vulgare* L. subsp. *vulgare* (72), *Cruciata glabra* (L.) Ehrend. s.l. (6), *Cyclamen hederifolium* Aiton subsp. *hederifolium* (42), *Cytisus scoparius* (L.) Link subsp. *scoparius* (70), *Dactylis glomerata* L. s.l. (70, 16), *Danthonia decumbens* (L.) DC. subsp. *decumbens* (61), *Dittrichia viscosa* (L.) Greuter s.l. (8), *Dryopteris filix-mas* (L.) Schott (41), *Equisetum palustre* L. (47), *Erica arborea* L. (15), *Erigeron canadensis* L. (37), *Euphorbia cyparissias* L. (72), *Fallopia convolvulus* (L.) Á. Löve (56), *Ficus carica* L. (56), *Fragaria vesca* L. subsp. *vesca* (2, 26), *Gagea lutea* (L.) Ker Gawl. (68), *Galega officinalis* L. (70), *Galium mollugo* L. subsp. *erectum*

Syme (69), *Geranium molle* L. (26), *Geranium purpureum* Vill. (41, 36), *Geranium robertianum* L. (21, 29), *Geranium sylvaticum* L. (10), *Gladiolus palustris* Gaudin (15), *Glechoma hederacea* L. (32), *Hottonia palustris* L. (43), *Hypericum montanum* L. (75, 39), *Hypochaeris glabra* L. (8), *Ilex aquifolium* L. (30), *Iris graminea* L. (68), *Iris pseudacorus* L. (13), *Juglans regia* L. (68), *Juncus conglomeratus* L. (43), *Juncus inflexus* L. (42), *Juniperus communis* L. (31), *Lamium maculatum* L. (58), *Lapsana communis* L. subsp. *communis* (62), *Lathyrus* sp. (43), *Lysimachia arvensis* (L.) U. Manns & Anderb. s.l. (45), *Lysimachia vulgaris* (L.) U. Manns & Anderb. s.l. (37, 43), *Melissa officinalis* L. s.l. (42), *Molinia caerulea* (L.) Moench s.l. (15), *Muscari comosum* (L.) Mill. (67, 68), *Myosotis scorpioides* L. subsp. *scorpioides* (43), *Narcissus tazetta* L. s.l. (15), *Oenanthe pimpinelloides* L. (62, 15), *Ornithogalum umbellatum* L. (67), *Orobanche purpurea* Jacq. (35), *Parietaria officinalis* L. (61), *Phillyrea angustifolia* L. (46), *Poa pratensis* L. (45, 48), *Polygonatum multiflorum* (L.) All. (30), *Polygonatum odoratum* (Mill.) Druce (42), *Polystichum setiferum* (Forssk.) T. Moore ex Woyn. (62), *Potentilla erecta* (L.) Raeusch. (42), *Prunus domestica* L. s.l. (75), *Pyracantha coccinea* M. Roem. (19), *Quercus petraea* (Matt.) Liebl. subsp. *petraea* (62), *Quercus pubescens* Willd. subsp. *pubescens* (69), *Ranunculus lanuginosus* L. (68), *Ranunculus polyanthemos* L. (16), *Ranunculus sardous* Crantz subsp. *sardous* (45), *Rumex acetosella* L. s.l. (15), *Rumex hydrolapathum* Huds. (8, 66), *Salix alba* L. (61), *Samolus valerandi* L. (1), *Schedonorus arundinaceus* (Schreb.) Dumort. s.l. (12), *Scilla bifolia* L. (68), *Scirpoides holoschoenus* (L.) Soják (6), *Sedum cepaea* L. (60, 64), *Serratula tinctoria* L. s.l. (15), *Silene dioica* (L.) Clairv. (61), *Silene dioica* (L.) Clairv. (61), *Solanum nigrum* L. (61), *Sorbus domestica* L. (62), *Stachys officinalis* (L.) Trevis. (42, 3), *Symphytum squamatum* (Spreng.) G.L. Nesom (26), *Ulex europaeus* L. subsp. *europaeus* (62), *Verbena officinalis* L. (16), *Veronica chamaedrys* L. subsp. *chamaedrys* (5, 58), *Veronica hederifolia* L. subsp. *hederifolia* (67), *Viburnum tinus* L. subsp. *tinus* (69, 71), *Vincetoxicum hirundinaria* Medik. subsp. *hirundinaria* (15), *Viola alba* Besser subsp. *dehnhardtii* (Ten.) W. Becker (50, 66), *Viola odorata* L. (15, 75).

Table 7 – *Alisma plantago-aquatica* L. (17), *Aquilegia vulgaris* auct. Fl. Ital. (10), *Arctium nemorosum* Lej. (16), *Bidens frondosus* L. (18), *Carex canescens* L. (4), *Chaerophyllum temulum* L. (1), *Chara* sp. (11), *Cirsium vulgare* (Savi) Ten. (16), *Cuscuta campestris* Yunck. (18), *Datura stramonium* L. subsp. *stramonium* (7), *Epilobium tetragonum* L. s.l. (10), *Eupatorium cannabinum* L. subsp. *cannabinum* (16), *Fragaria vesca* L. subsp. *vesca* (10), *Galium rotundifolium* L. subsp. *rotundifolium* (10), *Hypericum montanum* L. (5), *Juncus effusus* L. subsp. *effusus* (7), *Juncus maritimus* Lam. (4), *Lactuca serriola* L. (13), *Ligustrum*

*lucidum* W.T. Aiton (5), *Lilium bulbiferum* L. subsp. *croceum* (Chaix) Jan (10), *Liquidambar styraciflua* L. (6), *Melissa officinalis* L. s.l. (6), *Mentha arvensis* L. (11), *Persicaria hydropiper* (L.) Delarbre (16), *Persicaria lapathifolia* (L.) Delarbre subsp. *lapathifolia* (18), *Phytolacca americana* L. (1), *Pinus pinaster* Aiton subsp. *pinaster* (9), *Prunus cerasifera* Ehrh. (5), *Ranunculus repens* L. (4), *Ranunculus serpens* Schrank subsp. *nemorosus* (DC.) G. López (10), *Rosa canina* L. (13), *Samolus valerandi* L. (4), *Saponaria officinalis* L. (17), *Scutellaria galericulata* L. (4), *Smilax aspera* L. (3), *Stellaria media* (L.) Vill. subsp. *media* (18), *Symphytum squamatum* (Spreng.) G.L. Nesom (10), *Tordylium maximum* L. (10), *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica* (17).

## Supplementary material 1

### Figure S1

Authors: Matilde Gennai, Antonio Gabellini, Daniele Viciani, Roberto Venanzoni, Lorella Dell'Olmo, Michele Giunti, Fabio Lucchesi, Francesco Monacci, Michele Mugnai, Bruno Foggi

Data type: The dendrogram resulting from cluster analysis.

Explanation note: List of the plant communities found in the current research and of those found by other authors in the past.

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Link: <https://doi.org/10.3897/PlantSociology.58.60421.suppl1>

## Supplementary material 2

### Table S1

Authors: Matilde Gennai, Antonio Gabellini, Daniele Viciani, Roberto Venanzoni, Lorella Dell'Olmo, Michele Giunti, Fabio Lucchesi, Francesco Monacci, Michele Mugnai, Bruno Foggi

Data type: phytosociological table

Explanation note: Phytosociological table of the *Dioscoreo communis-Populion nigrae* Poldini et Vidali in Poldini, Sburlino et Vidali, 2017 association.

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